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ABSTRACT

Intended for use in middle and junior high schools, these nine classroom and field activities help students better understand the great diversity of natural communities and the complex interactions of aquatic organisms. A background information section presents teachers with an overview of wetlands, streams, lakes and ponds, and puddles. Classroom activities ask students to view films, participate in a food web exercise, create indoor wet environments using jars and a small children's plastic swimming pool, decorate the classroom with art projects, and study the human history of salt marshes. Field trips allow students to investigate a stream, saltwater marsh, lake, and the school-site watershed. Each activity outlines the objectives, field site when appropriate, materials, timing, and procedures. Teacher resources include lists of organizations, people, teaching units, places to visit, books, and films. Information sheets and student handouts are also included. (DC)

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What Adventures Can You Have in Wetlands, Lakes, Ponds, and Puddles?

A Marine Education Infusion Unit on Wet Environments

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Northern New England Marine Education Project

The objective of NNEMEP is to encourage and support marine education among the teachers of Northern New England so that their students will appreciate the importance of water in their lives and in the life of the planet. The project has received support from the College of Education of the University of Maine at Orono, the National Science Foundation, and the Maine-New Hampshire Sea Grant Program.

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Revised Marine Education Infusion Units for Middle School-Junior High School

Have You Been to the Shore Before? A Marine Education Infusion Unit on Seashore and Aquarium Life

What Adventures Can You Have in Wetlands, Lakes, Ponds, and Puddles? A Marine Education Infusion Unit on Wet Environments

What is Our Maritime Heritage? A Marine Education Infusion Unit on Ships and Shipping

Is Our Food Future in the Sea? A Marine Education Infusion Unit on Aquaculture and Sea Farming

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Original — Trial Editions (For Grades K-12)

Clams and Other Critters
Marine Art
The Aquarium
The Beaver
The Lobster
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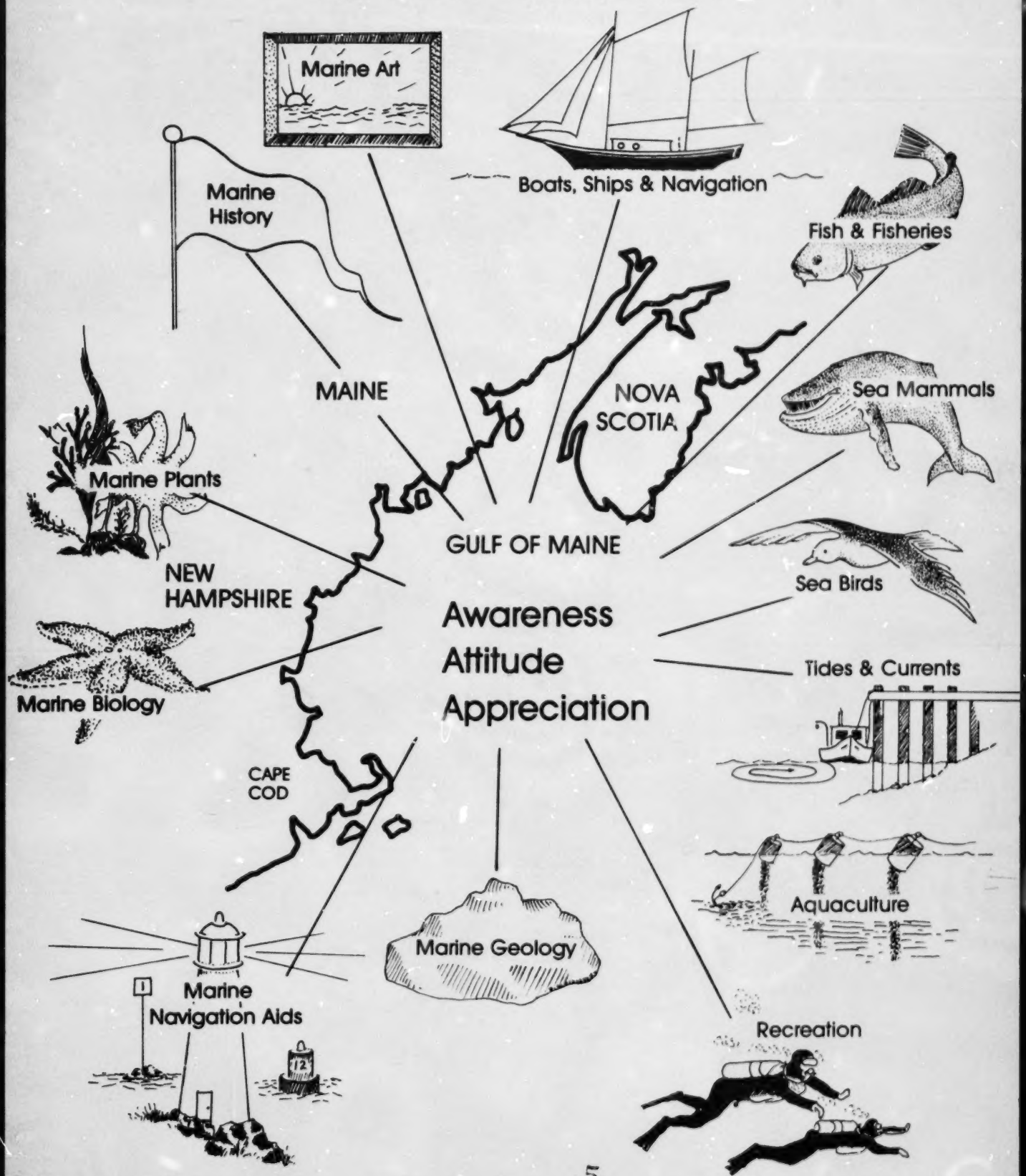
Our Heritage of Ships
Shipping, Ships and Waterways
The ABCs of Celebrating Year of the Coast in Your School
Have You Ever Been to the Shore Before?
Blue Mussel
Lighthouses
Wetlands
Seaweeds
Aquaculture
Navigation

More than one hundred teachers and members of past NSF sponsored summer institutes have trial tested and critiqued these units.

Marine Education

Ocean & Coast Conceptual Scheme



Foreword

Marine education is a relatively new term embracing a multi-disciplinary approach to learning about the marine environment: how it relates to people and how people change and relate to it. These units are intended to serve as points of departure for teachers and students who desire to increase their awareness of the watery world of this blue planet. Each unit includes ideas and activities drawn from a variety of content areas so that teachers of many different subjects at the junior high and middle school levels can make use of them. These units may be used in their entirety or used as idea or activity sources to infuse into the usual curriculum.

Our objective is to help teachers make learning more water-related. We did not plan a structural sequence of topics for grades five through nine, but rather offer these teachers guides and student pages for your consideration.

The general focus within these units is the Gulf of Maine. As the Gulf extends from Cape Cod to Nova Scotia it washes an extremely long and varied coast. We have dredged and seined themes from the activities, concerns, organisms, vessels and the past of this vast watery region of North America. We aim to be inclusive rather than exclusive, suggestive rather than factual, and stimulating rather than expert. Our hope is that your students will become more questioning, interested, and critical of watery concerns. We hope your use of these materials will add water back into our culture.

John W. Butzow

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Teacher Background Information

The broad purpose of marine education is to develop a marine literate citizenry; that is, to educate our students about the fundamental importance of the connections of human culture to the marine and aquatic environment. The general purpose of the marine education infusion units in this series is to provide teaching materials to make this broad purpose possible for middle and junior high school teachers in Northern New England. The special purpose of* What Adventures Can You Have in Wetlands, Lakes, Ponds, and Puddles? *is to make available teacher-tested ideas and activities for use in your classroom and on your field trips to wet environments.

The important concepts in this unit are the great diversity of natural communities and the complex interactions of aquatic organisms. Specific objectives are given for each activity but bear in mind two general objectives. Students should develop improved knowledge and increased appreciation of the beauty and complex interrelatedness of life.

This unit is not a step-by-step piece of curriculum; it is designed to allow flexibility on your part. It will be necessary for you to adapt the material to your students' abilities and needs, your access to materials, and the possibilities for outdoor excursions.

The Northern New England Marine Education Project values teacher input. This unit will be introduced in workshops throughout the bi-state region; we welcome your reactions and ideas for improvement. Feel free to contact us.

An Introduction To Wetlands

Wetlands are areas where saturation with water is the dominant factor determining the nature of soil and the types of plant and animal communities living in and on that soil. For the purposes of human study and management, wetlands definitions have been developed by the United States Fish and Wildlife Service of the Department of the Interior. For technical definitions and background, we recommend two of their publications to you; *Classification of Wetlands and Deepwater Habitats of the United States* and *Wetlands of Maine*. These are available from the Regional Wetland Coordinator, U.S. Fish and Wildlife Service, One Gateway Center, Suite 700, Newton Corner, Massachusetts 02158, telephone (617) 965-5100, extension 385. Maps in the National Wetlands Inventory are also available from this office.

The classifications used here are from the *Wetlands of Maine* report. These descriptions should help students understand the basic differences among wetland types. The three general categories—inland fresh areas, coastal fresh areas, and coastal saline areas—contain a total of fourteen specific types which are briefly described here.

Inland Fresh Areas

Seasonally Flooded Basins, or *Flats*, are found along stream courses. The soil is usually well-drained during the growing season and often in agricultural use. They are used at times by feeding ducks, if they are flooded while food plants are available.

Fresh Meadows. The soil is waterlogged throughout most of the growing season. The vegetation consists mainly of various grasses.

Shallow Fresh-Water Marshes. The soil is normally water-logged during the growing season and may be flooded at times with as much as fifteen centimeters of water. Vegetative types are usually grasses, cattails and bulrushes.

Deep Fresh-Water Marshes. The soil is covered with fifteen centimeters to one meter of water. Vegetation consists mainly of cattails, round-stemmed bulrushes, wild rice, and various other emergent true aquatic plants.

Open Fresh-Water Marshes. These marshes are covered by open water up to three meters deep with floating leaf plants and submerged vegetation. Common plants are pond weeds, coontail, spatterdocks, and water lilies.

Shrub Swamp. The soil is normally waterlogged during the growing season. It may be covered with as much as fifteen centimeters of water. Vegetative types are usually alder, button bush, dogwood, and perhaps willow.

Wooden Swamps. The soil is normally waterlogged during the growing season. The swamps are timbered with tamarack, red maple, and black spruce.

Bog. The soil is usually waterlogged at all times. Vegetation in Maine consists of various heath plants and sedges. Common representatives are leather-leaf, sphagnum moss, cranberry, sedges, and labrador tea.

Coastal Fresh Areas

Shallow Fresh Marshes. The soil is always waterlogged during growing season and may be covered by as much as fifteen centimeters of water at high tide. Vegetation consists mainly of grasses, cattails and sedges.

Deep Fresh Marshes. The soil is covered with from fifteen centimeters to one meter of water at high tide during the growing season. Common plants are cattails, pickerelweed, and wild rice.

Open Fresh Water. The soil is covered with water of variable depths, usually less than three meters. Vegetation consists of floating and submerged aquatics such as pondweeds, coontail, and wild celery.

Coastal Saline Areas

Salt Meadows. The soil is always waterlogged during the growing season but rarely covered with tidewater. The most common plant is saltmeadow cordgrass.

Regularly Flooded Saltwater Marshes. The soil is covered at average high tide with fifteen centimeters or more of water during the growing season. The main plant cover is saltmarsh cordgrass.

Sounds and Bays are mud flat areas laid bare at low tide. No appreciable amount of vegetation has been observed on the mud flats in Maine.

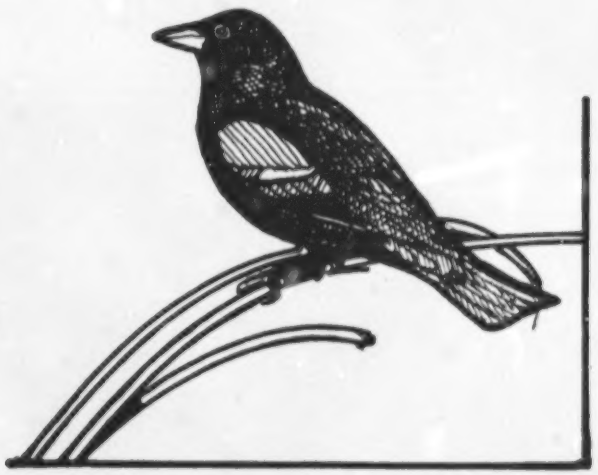
We will focus in this Introduction To Wetlands upon two broad types—the fresh-water marsh and the saltwater marsh, and upon the bog. Beyond the background provided here we encourage you to refer to the multitude of excellent resources available on marshes and other wetlands. We have annotated those which we feel are most appropriate for grades five through nine in our filmography and bibliography.

The Fresh-Water Marsh

The shallow waters are warm in spring and summer, and the nutrients carried in by the stream are captured to support an abundance of life. Waving cattails, bulrushes, and horsetail form thick growths where the water is not too deep; even apparently empty areas have dense submerged plant life.

Marshes provide habitat for a great variety of birds. To many, spring arrives with the flash and call of a red-winged blackbird and the skimming of swallows over the emerging green. Even ducks forget their wariness. One might see a long-legged bittern stalking frogs and minnows, or curving its neck and calling, sounding for all the world like someone driving fence posts. Common snipe winnow overhead.

About the only mammals that show up in the daylight hours are the muskrats—sunning themselves, feeding, or repairing their homes. As dusk falls, other animals start to move. A beaver might pass through searching for a spot suitable for a new home, and perhaps finds enough food here. Raccoons and mink prowl with success. The frog chorus begins to sing. The roar of spring peepers deafens almost everything else. This tiny frog with a cross on his back can be difficult to find. It sits in a bush near the water's edge, calling with hundreds of fellows, until one comes near. Then it stops. The solution is to stay very still and try to outwait it. Then, one might catch a glimpse.



Green and leopard frogs call from the water, and everywhere there is the high-pitched whirr of toads who have returned to the water for the first time since they left it when they were one week old and a quarter inch long.

At no time of year is there more visible life in the marsh than spring. The warming water leads to a sudden surge of plant life which feeds insects and other invertebrates. These tiny animals in turn feed the hordes of emerging amphibians and young birds.

As summer advances and the cattails grow, animals become less apparent. In fall, the rushes fade and die, the waterfowl leave, the frogs burrow into the bottom muck, and the muskrats finish off their winter homes.

By winter, the only sign of life might be the trail of a solitary fox, circling patches of dead cattails and wandering away from a dug-up muskrat house. No matter what the season, the fresh-water marsh is a rich and important environment.

Fresh-water marshes account for nine out of every ten acres of marsh in America. They serve as water purification systems by taking up human-produced pollutants as nutrients. Wetlands reduce the severity of floods by absorbing vast amounts of water. Often their value goes unappreciated and they are filled, dredged, and altered. Forty percent of America's wetlands have been destroyed.

The Saltwater Marsh

Tidal marshes have different values to different people. The real estate agent sees them as having great potential once drained and filled. Many others see them as havens for a variety of wildlife.

If left as a natural ecosystem, what is a marsh's real value? The marsh grass serves as a source of potential energy. This energy source is continually being tapped by marsh grass herbivores and bacteria. Mechanical breakdown by waves and tidal flow is also constant. Energy, in the form of particulate organic matter or detritus which contains essential nutrients such as phosphates and nitrates is continually being released into other areas of the ecosystem.

These nutrient salts are as vital to the growth of aquatic plants as they are to that of terrestrial plants. Nitrates and phosphates released from the marsh storehouse are taken up by the microscopic aquatic plants, known as phytoplankton, as well as by the large algae and aquatic spermatophytes. The nutrients which are incorporated into their tissues, are also taken up by the living marsh grass to be stored and eventually released. The detritus may be utilized immediately as food by a variety of organisms in the ecosystem, including small fish, shellfish and crustaceans. This nutrient soup is a source of the richness of marsh life.

As the phytoplankton flourish on the contributions of the marsh, they form the primary link in the aquatic food chain. That chain extends through a series of consumers—herbivores and carnivores—and ultimately to a form of food that may be utilized by people in the form of larger fish and shellfish. At all links in this chain, death and decomposition continually occur, making nutrients available in a form that can be used by different plants and animals in the ecosystem.

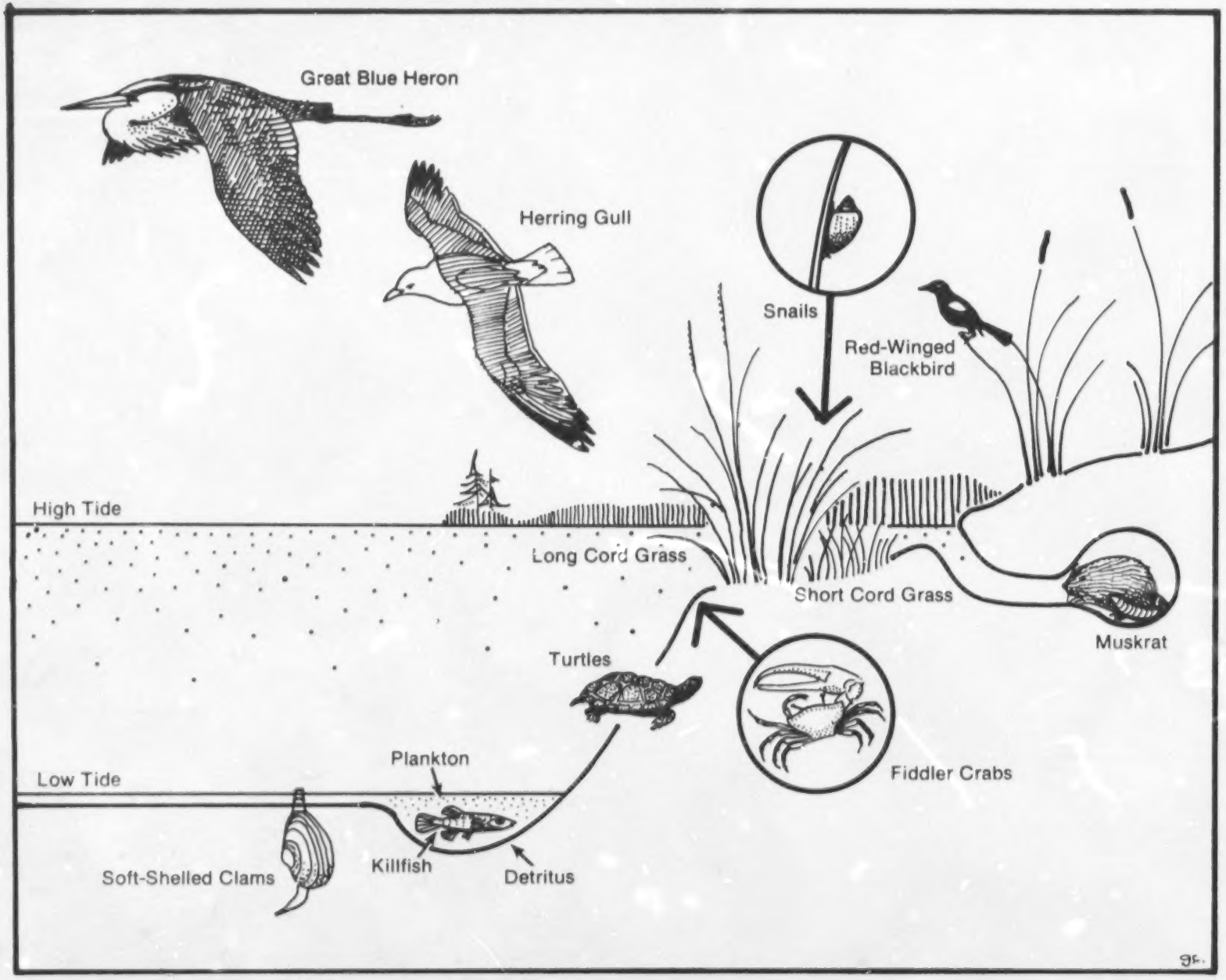
One of the unique features of the tidemarsh ecosystem is the fact that much nutrient material is not lost, but is efficiently retained within the system. Tidal ebb and flow continually distribute nutrient material in its various forms throughout all parts of the system. Because the life cycles of such organisms as bacteria, phytoplankton, and the smaller animals inhabiting the system are relatively short, the turnover is rapid and nutrients are seldom locked in unusable form for long periods of time. In this way, the system is self-sustaining.

How do the sea fisheries, and therefore people, benefit from the estuarine-tidemarsh ecosystems along the coastlines? The answer is that many species which are of tremendous economic value depend upon this type and of environment during all or part of their life cycles. Oysters, shrimp, and manhaden subsist largely on the organic materials provided in the estuarine-tidemarsh environment. It is also the nursery for many other important species of fish and shellfish.

Salt marshes are among the most productive areas in the world in terms of basic nutrients - proteins, carbohydrates, and fats. This may vary from a production of 27.5 to 110 kg of nutrients per acre per day.

Two and one-half tons of nutrients per acre per year are flushed into the sea as basic food for sea animals. These nutrients are passed along through a whole complex of food chains and webs and are essential to the production and maintenance of shellfish and finfish, waterfowl, and furbearers— as well as people.

Life of the Salt Marsh



Adapted from the Massachusetts Audubon Society, Lincoln, MA 01773

The Bog

Inhabited by sphagnum moss, cotton grass, sedges, rhodora, Labrador tea, cranberry, leather leaf, sundews, pitcher plants, bladderwort, orchids, black spruce, and larch, bogs are one of the most unusual and beautiful wetlands in Northern New England. Rare plants give them a special educational and scientific value. To survive in bogs all plants have evolved adaptations to acidic and nutrient-poor water. Deer, moose, and rabbit tracks are found in bogs although little is known about the utilization of them by mammals.

Once left alone and seldom visited except by hardy botanists, the economic value of bogs is now being intensively explored. The great value of peat as an agricultural amendment to revitalize soil and its potential value as a fuel source will make the use of peatlands an important issue in the next few years. This would be an excellent and timely source of research projects and class discussion.

An Introduction To Streams

The Physical Nature of the Stream Habitat

Natural woodland streams tend to have alternating riffle or shallow and pool or deep areas, especially where the stream bottom is coarse. These areas tend to alternate at regular intervals when the substrate is gravelly. The larger particles in the substratum, such as stones, gravel, and boulders, are most common in riffle areas. Finer silt, sand, and organic detritus particles accumulate in the pools. The occurence of the riffle and pool pattern in most streams is a product of a variety of physical forces exerted by the running water and by the material through which the water flows. This pattern has a great effect on the stream biota.

Riffles are characteristically shallow water areas of the stream. The water velocity usually reaches a maximum here. This factor, coupled with the large size of the stream bed particles, gives a turbulent, roiling nature to the flow. Such turbulence is important in initiating displacement and downstream movement of gravel and small rocks, but of biological important is its aeration property. Oxygen and carbon dioxide from the atmosphere mix with the stream water and thus are made available to stream organisms. Higher stream velocity in the riffle area also precludes the accumulation of fine organic and inorganic sediments and limits the number of aquatic plants that are able to grow there. Although small organic materials move through the riffle area, large organic debris like leaves, sticks, logs, may often collect around the large streambed particles. This material may provide food and shelter for a number of aquatic insects and other organisms.

Pools are generally the deeper areas of the stream where water velocity is reduced and more uniform. Sand, silt, and fine organic matter, which are displaced from upstream riffle areas, accumulate on the stream bottom, providing a good habitat for rooted aquatic plants. In some pools, accumulations of coarser organic matter like dead aquatic plants or tree leaves can occur. Alcoves and stream margins tend to follow similar patterns.

Temperature

The temperature of stream water varies much more rapidly than that of rivers or lakes. Due to the turbulent nature of the streamflow, stratification is not possible. Daily temperature cycles are often exhibited with maximum temperatures usually occuring in the afternoon and minimum temperatures occuring shortly before sunrise. Seasonal temperature patterns are also evident.

Stream temperature may be modified by many factors. Spring-fed streams tend to show a more constant pattern of water temperature than do other types of streams. They are cooler in summer and warmer in winter than other streams. Shading by streamside vegetation will reduce solar radiation and keep a stream cooler. The source of water flowing into the stream may also greatly affect the temperature. Groundwater or snowmelt water will cool the stream; water flowing in from sun-warmed fields or woods will increase stream temperature.

Water Chemistry

One chemical characteristic of stream water which is of great importance to aquatic life is the occurrence of dissolved gases. The two gases essential to life, oxygen and carbon dioxide, are normally at or above saturation levels in the water of small turbulent streams. This phenomenon, however, may be modified by a number of factors: the occurrence of aquatic plants, the water

temperature (cooler water holds more oxygen than warmer water), the accumulation of organic matter, and the source of the stream water (for example, spring water is often completely de-oxygenated).

Other chemical characteristics which may affect stream biota are alkalinity/acidity (pH), the occurrence of dissolved ions, and the presence of inorganic or organic pollutants, and toxins.

Human Use of the Stream

Recreational uses of the stream are important, especially in the sport of fishing. Trout and salmon are part of the aquatic food chain that are indicators of the health of the stream environment and are sought by fishermen. Changes in the natural balance of the stream has adversely affected the biota and resulted in the loss of these sport fish in some waters.

Proper management of the streams and rivers to accommodate all organisms ought to be considered in human projects, such as when large dams and check dams are being constructed. Other projects on rivers and streams have led to the placing of boulders and rocks along the banks, calling riprapping, and the channelization of stream beds and banks.

Urbanization and suburbanization can affect the stability of the slopes surrounding the stream and cause erosion. Runoff from storm sewers often flows into streams which increases their velocity. This causes the natural banks to erode. An increased flow of water causes flooding downstream which is undesirable to residents there. The natural meander is a marvelous habitat for organisms, especially in the pools. It is quite aesthetically pleasing to observe a stream in this state of equilibrium. Urbanization necessitates the riprapping or channelization of the stream in order for the water to flow more quickly to the area of deposition and cause less damage to the property owners. Urbanization upstream may also cause the dumping of refuse and settling of the land as well as erosion. This affects the downstream area again. This is a source of pollution—the presence of matter or energy whose nature, location, or quantity produce undesired environmental effects.

An Introduction To Lakes And Ponds

"It was only an ordinary pond, in an ordinary field belonging to an ordinary farmer; but to those who had eyes to see, it was full of marvelous things. It was a small world in itself, and to the wonderful creatures that were born, lived, and died there, no doubt it seemed a very big place indeed. . ."

Anne Helena Woodruff
The Pond in the Marshy Meadow (1906)

Ah, the eyes to see. The teacher background information provided here attempts to help you open your students' eyes to see the beauty and value of Northern New England's ponds and lakes. Whether you focus on Lake Winnipesaukee or the nearby frog pond, there is magic for youngsters in the water of these wet environments. We encourage you to teach about many aspects of them and have provided information across several disciplines.

The Formation of Lakes

Glaciers formed almost all lakes in Northern New England by one of three methods. First, hollows were scooped out by moving ice. Second, valleys were filled behind dams of glacial debris. Third, rain flooded glacial kettleholes which were originally made by large pieces of ice pushed underground. Ice later melted and left unusual shaped depressions.

Glacial formation can be explained to youngsters by asking them what happens when you take a snowball and pack it very tightly—on a tiny scale this is what gives birth to a glacier. Snow one hundred to two hundred feet thick moves because it cannot support the weight of ice above it; it becomes a river of ice. The tremendous force of this glacier moved huge boulders and rock debris. Today these glacial erratics can be found around Maine lakes.

The process of lakes and ponds changing over time to forests is called succession. This process is at work in even the youngest ponds. When a pond is first established, pioneer plants colonize its shores and bottom. As these plants decompose, the bottom is enriched with organic nutrients and new types of plants take root. As they decay, still other types will grow; gradually, sediment accumulates and the shores fill in. This process takes many years depending upon the size of the body of water and certain geologic factors. Each stage in succession allows particular plants and animals to thrive.

Differences

Oceans are salt water, whereas most lakes are fresh water. Oceans have tides and lakes do not. Many species of wildlife, fish, insects and plants are indigenous to either the lake community or to the ocean community, but not to both.

A natural lake over ten acres is called a Great Pond. An artificial lake over twenty acres is also a Great Pond. Although Maine law defines great ponds, the difference between a lake and a pond is a matter of local custom. There are 2926 lakes in Maine larger than ten acres and 2000 lakes between one and ten acres. This means there is a large lake for every 11.5 square miles (30 kilometers^2) and every 340 residents. Four and one half percent of Maine is covered with fresh water; Northern New England is water-rich compared to much of the world.

Pollution

The biological health of a lake can be threatened by many human activities. Industries and utilities contribute to the pollution of lakes by adding chemicals and sewage to the water. These can kill living organisms. Sometimes water is used as a coolant and returned to the lake at a temperature too high for the tolerance of living organisms.

Erosion of soil into lakes is increased by tree harvesting, agriculture, and alteration of the shoreline. The silt which runs off into a lake can be destructive to wildlife and water quality. Human habitation on farms, in year-round homes, and in summer cottages can contribute to degradation of water by adding sewage, fertilizers, insecticides, and other chemicals. A condition called eutrofication, which is high organic content and low oxygen content, can be caused by runoff.

Water becoming dirty and unusable is harmful to the wildlife and plant life of the lake. Polluted water also destroys the economic resources of the lake by precluding its use as a public water supply or recreation area.

Management

Human management of lakes is common in Northern New England. Water levels of lakes are often controlled by dams and locks. State governments manage fish speciation and wildlife populations through game propagation, fish culture, and hunting and fishing laws.

Some lakeside areas are managed as parks and preserve lands. Water quality and development are closely monitored by state resource agencies. In Maine and New Hampshire, citizens have become increasingly involved in processes through which they can impact the quality of lakes. Private lake associations formed to protect lakes are very common in Maine and are organized into a single voice as the Congress of Lakes Association (COLA). Private state-wide conservation organizations also play a role in influencing lake management.

Economic Resources

Careers that are dependent upon a lake area are innumerable. The economic success of the lake area is linked to the need for these jobs. Inhabitants of summer cottages need the services of masons, carpenters, plumbers, electricians, power and telephone companies, physicians, dentists, shops and stores, mechanics, gasoline service stations, a postal service, and realtors. Girls and boys camps utilize these and many others. They also hire people to staff the camps.

Public campgrounds and state parks require management, service, and maintenance. Marinas supply needed sales and service to boat owners and renters. Tourism, an important aspect of any developed lake area, needs restaurants, theatres, gift shops, sports shops, and public recreation of many kinds.

State involvement in the lake area includes administration and resource management, and enforcement of fish and game laws. A lake that is a public water supply has need of engineers, chemists, and managers—among others. There is little commercial fishing in inland waters except for live bait and eels.

Living Things of the Lake

Students find great interest in the living things of the lake ecosystem. We include species found in and around the lake—any plant or animal that is part of the lake's web of life and is dependent upon other members of the lake community.

Animals include moose, beaver, muskrat, osprey,

loons, ducks, geese, newts, turtles, raccoons snakes, songbirds, and many more. Plants include water plants and shore plants, such as water plaintain, water lillies, arrowheads, sweet flag, calla, cattails, duckweed, ferns, water cress and many, many more.

Among the many fish found in lakes are landlocked salmon, togue or lake trout, bass, white and yellow perch, sunfish, pickerel, smelts, cusk, catfish, eels, suckers, and minnows. The three most important game fish are landlocked salmon, togue and small-mouth bass.

The landlocked salmon spawns between October and November in a gravelled area of a lake outlet. She digs pits by turning on her side and flapping her fins. The fry emerge from the gravel in June and feed on water insects. The older young, called parr, remain in the river or stream for one or two years. They then go into the lake and feed on fish—smelts, yellow perch, and minnows.

The togue, or lake trout also spawns between October and November. She lays her eggs on coarse gravel or a boulder-covered bottom. There is no nest. The male cleans the rubble by swimming close to the bottom and occasionally flips rocks out of the way with his fins. The female arrives and spawns. Little is known of the togue following the sac fry stage. It is possible that the young go into deep water to grow. The adult is a fish eater; if it is really hungry, it will eat plankton.

The small-mouth bass is a valuable game fish. The nest is prepared by the male who cleans a circular area in coarse gravel. Spawning takes place in June. The male guards the eggs, keeping them clean with fin movements. He also guards the young fry in the gravel. These gradually darken and become black fry which rise up into the water and move from the nest. The young feed on minute animals and plankton. Older bass however prefer fish and crayfish for food.

Some of the insects found around lake areas include water beetles, dobson flies and hellgramites, giant water bugs, water striders, caddisflies, dragonflies and damselflies, stoneflies and mayflies. Insects are extremely important as food for fish.

The whirligig beetle is a familiar little metallic-black insect which circles and skims on top of the water. It has a double set of eyes for underwater and abovewater vision and feeds on dead animal matter and vegetation.

Hellgramites, which are immature dobson flies, feed on mayfly and stonefly nymphs and serve as bait for bass. Dragonflies and their smaller counterpart, damselflies, are bright colored and quick in flight. They are mosquito killers while the nymph is good for fish. They have double wings, double eyes, and three pairs of legs.

The mayfly is an extremely important food for gamefish. Since it provides surface feeding for trout, many an angler is happy to see a swarm of mayflies hovering over a pond. The nymphs are aquatic and feed on plants and algae. The adult lives only a day or two.

Human History

We recommend choosing either a local lake familiar to the students or a well-known lake with statewide significance for the study of human history. There are many resources available for your research. Books and periodical literature are often found in the local library. The local lake association or historical society may have print resources or the names of knowledgeable individuals available to visit your class. It is important to remember to include both Native American and settlers history in your study.

An Introduction To Puddles

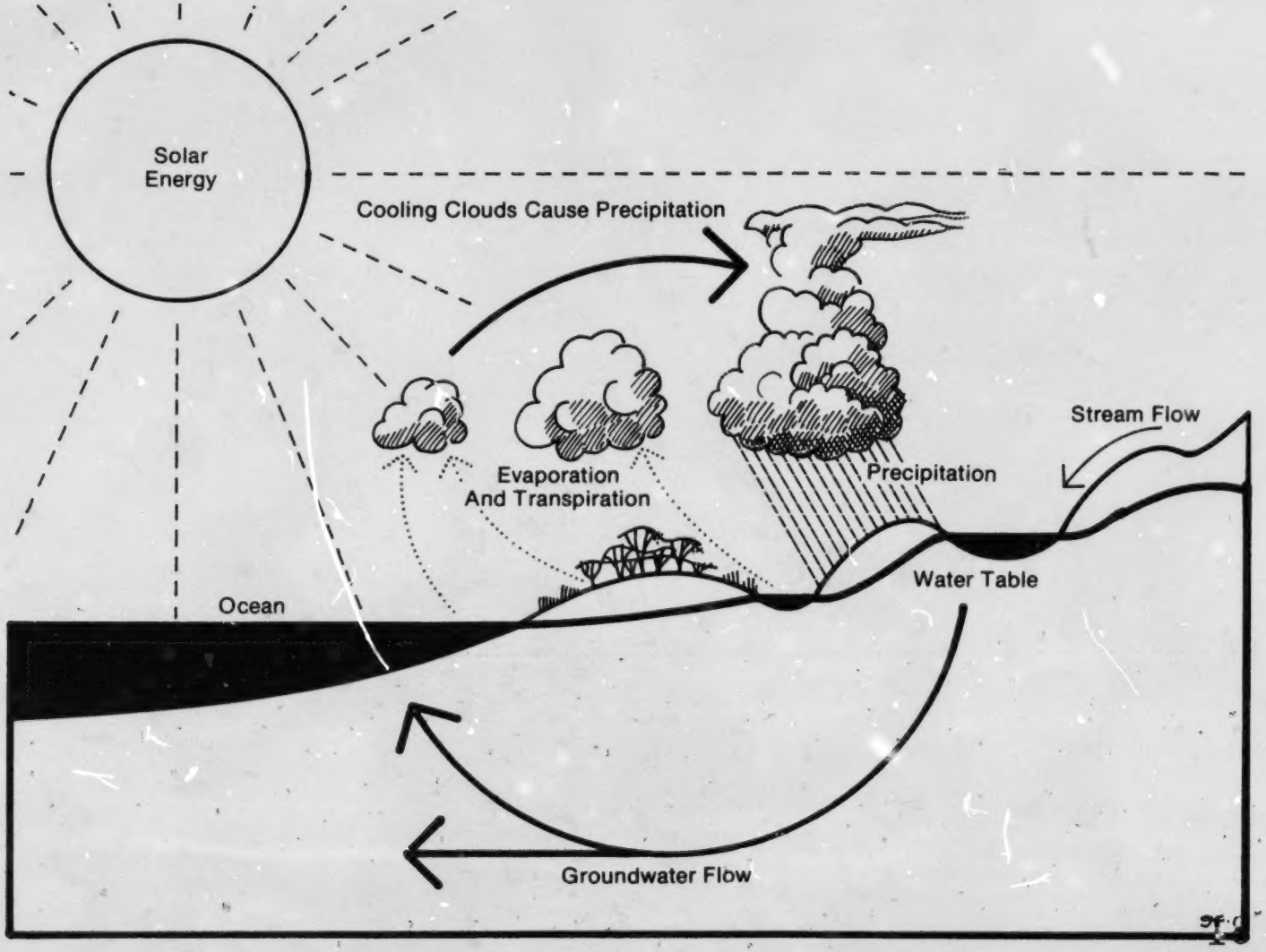
Many aspects of the hydrologic cycle can be taught using playground or nearby puddles. The key concept involved is that of the watershed—that land area drained to a defined point, such as a stream or river. A watershed channels and holds the rain water which falls on it. Major watersheds that are commonly referred to in Northern New England are those of the major rivers like the Piscataqua and the St. John. Maine and New Hampshire enjoy an abundant and high quality water resource. The region has a moderately high level of precipitation, low densities of population and industry, and extensive forest cover. The forest cover and wetlands hold rainwaters, maintain groundwater, and even out stream flows.

Your school site is part of a watershed. Every drop of rain or flake of snow which falls on it enters the water system. The school grounds can be used to teach about water drainage. When rain falls, the amount which enters the ground depends upon ground cover. A forest cover, for example, slows the runoff and some of the rain moves down into the soil to become part of the permanent water table which supplies the land. Rain will run off into storm drains from paved surfaces.

A watershed is a complex maze of waterflow across the land. Puddles are shallow, temporary collections of rainwater. They may last a few hours or a few weeks, as in the case of vernal ponds. These are formed by heavy spring rains and form an environment conducive to the growth and reproduction of small plants and animals. Populations of aquatic organisms change in response to physical and chemical changes.

Water quality can easily be degraded by surface mining, clear-cutting of forests, waste disposal, and a host of other human activities which alter the delicate ecological balance toward which nature moves. Acid rain is produced when airborne sulphur and nitrogen oxides combine chemically with moisture in the air to produce diluted sulfuric acid and nitric acids. These acids, which enter the

Hydrologic Cycle



surface and groundwater, become one of the most serious environmental problems in Northern New England.

The puddle is a body of water which is part of a much larger system, the hydrological system or hydrologic cycle, by which water is cycled back to the upper reaches of the watershed. Cycling is the process by which nutrients move back and forth between the living and nonliving components of an ecosystem.

By examining the flow of water through school drainpipes, gutters, gullies, and puddles, much can be learned about natural processes and extended to the study of wet environments. We encourage you to engage in mapping activities, to monitor flowage, to identify problems, and to study aquatic life in puddles on the school site and relate this to the concept of larger watersheds.

19

Classroom Activities

Film Field Trip And Follow-up

Objective: ***To explore the species and energy flow in a marsh through the medium of film***

Materials:
- Classroom copies of the marsh pre- and post-tests found in the pocket of this guide on page 49.
- Copies of one or both of the films around which this activity is planned

Timing: Two class periods

Procedure: This lesson would serve as a good introduction to your study of wet environments, especially if a field trip is unavailable. The pre-test would be a useful tool for your assessment of student awareness about marshes. This would be followed by viewing one or both of the films and class discussion and questions. On the second day you could teach a lesson on marshes, administer the post-test, and discuss further the science and issues involved. These introductory days could be followed by other activities and in-depth student projects on aspects of particular interest to them. The marsh pre-test and post-test may be found in the pocket on page 49. This sheet may be thermofaxed and cut into two pieces for use on the two days of this activity.

Pretest Answers:

1. A marsh is a tract of soft, wet land. Many variations of this answer may be accurate.
2. One might find muskrats, ducks, and geese of all kinds, raccoons, shellfish, finfish, herons, gulls, egrets, loons, redwing blackbirds, crabs, and many others.
3. In saltwater marshes, one might find sedges, rushes, saltwort, timothy grass, and the two common cordgrasses *(Spartina alterniflora* and *Spartina patens).* In freshwater marshes, one would possibly find such plants as pink martin, pond lillies, water buttercups, marsh marigold, cattails, pickerelweed, and even marsh mallow.
4. Marshes provide food, water purification, flood control, waterholding capacity, recreational and education opportunities, and beauty.
5. Marshes contribute to animal life with food, shelter, and an environment for life and breeding.
6. People may have a great variety of positive or negative impacts on a marsh from protection to destruction.

Post-test Answers:

1. Diatoms and related phytoplankton and zooplankton are consumed by larger organisms such as barnacles and snails. Detritus provides nourishment for shellfish and crustaceans which are eaten by gulls and other forms of wildlife. Small fish which eat smaller forms of marine life are eaten by larger fish and waterfowl. Waterfowl may also eat marsh plant life. People are part of the marsh food chain because they consume fish, shellfish, and waterfowl.
2. Any of the following may destroy a marsh: storms, rise in sea level, dredging, filling, pollution.
3. Marshland is being set aside as wildlife preserve. Concerned groups are taking legal action to prevent pollution of marshes. Public education programs have also been established to increase awareness of the value of the marshes.
4. Many species within each of these types may be found: animal life - muskrats, raccoons, deer, waterfowl, fish, shellfish, crabs, and plant life - phytoplankton, algae, marsh grasses, and flowers.
5. Marshes are important in the regulation of flooding, the establishment of high water tables, and the provision of water in times of emergency. Marshes are important as the nursery ground or winter stopping point for many forms of waterfowl and marine life. The abundance of life in the marsh not only plays a significant role in the food web, but also provides aesthetic and recreational opportunities for people.
6. There are many answers to this value-laden question. It could be a starting point for a class discussion of the value of marshlands.

Films

Salt Marsh: A Question of Values was produced by Encyclopedia Britannica in 1975. It has excellent color photography and is twenty-two minutes long. It is available from the University of Maine at Orono; directions for ordering may be found in the Annotated Filmography. It is most appropriate for older students.

This is a well-organized, concise film on the ecology of marshes, ending with discussions of reasons they should be preserved. It clearly illustrates concepts of food webs and energy in a marsh. The narration is oriented toward describing the processes taking place in the marsh. The nursery concept, energy flow, and food supply are emphasized—as is the value of marshes.

The following questions could be given to the students prior to seeing the film so that they will

have a specific purpose in mind while viewing the film. After the film, these questions should be thoroughly discussed.

1. Where are salt marshes most commonly found? Which plant species dominate the marshes along the Eastern coast of North America?
2. How do tidal currents from the sea benefit the growth and productivity of marsh plants?
3. Briefly explain how marsh grasses have adapted to the high salt content of the estuaries.
4. What is the basic source of energy production in estuaries?
5. Describe, in general, the estuarine food web.
6. What is detritus? How is it formed?
7. Briefly describe the methods scientists have used in measuring the productivity of the salt marshes? What do these studies show?
8. What effect have projects to reclaim the marshlands had on the estuarine environment? How have these projects effected commercial fishing operations?
9. What did you find most interesting about the film?

Marsh Adventure is also available from UMO. It was produced in 1954 and shows its age in poetic dialogue and romanticized and slightly overdone statements. Nonetheless, it is a worthwhile film which captures the sights and sounds of a marsh in our part of the world. It is nineteen minutes long and in color. You might show it once with a piece of music playing and then with its sound track.

This film was produced by the Maine Department of Inland Fish and Game, and consists of excellent wildlife photography of a typical Maine marshland. It shows the importance of the marsh to wildlife and depicts some of the interrelationships of plants and animals in this kind of environment. The marshes shown are basically fresh water marshes. The plant and animal life described is typical of such marshes in Maine and New Hampshire.

The following questions could be given to students prior to their first or second viewing. The chart referred to in question one may be found in the pocket on page 48.

1. Fill in the chart as you follow the film. Then you will have the main plants and animals found in the Maine fresh-water marshes. Be ready to set up a food web using the above information.
2. What information did you find out about: a) the loon, b) the muskrat, c) the osprey?
3. What do you consider to be the main value of a marsh?
4. To what extent should marshes be filled in or drained to be used for other purposes?
5. How do people use marshes?
6. How is a marsh formed?

A Marsh Food Web

Objective: ***To demonstrate graphically the interconnectedness of living organisms in the marsh***

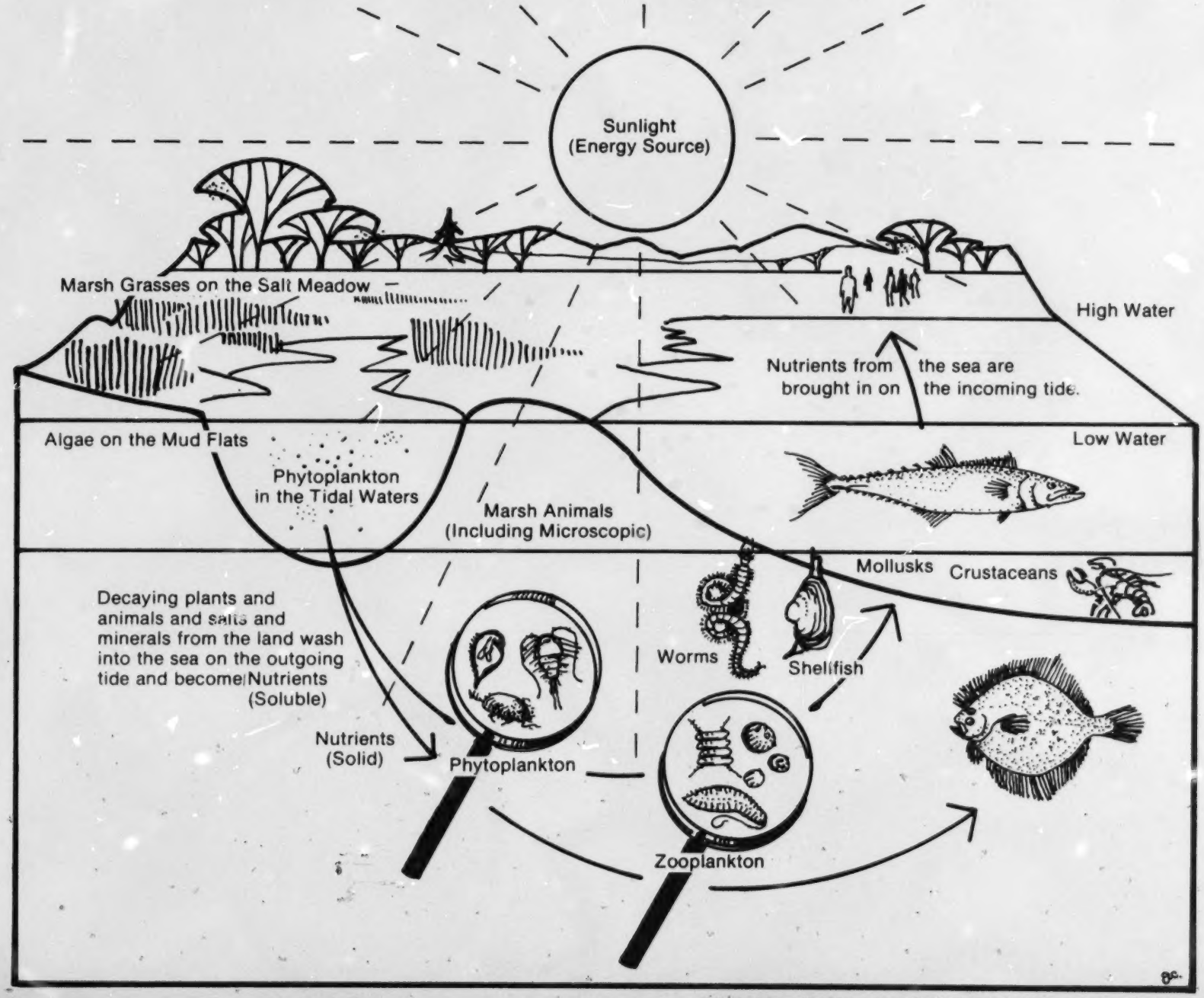
Materials:
- Thin string
- Cards each with the name of one marsh organism
- Classroom copies "Salt Marshes - Food for the Sea" found on page 13.

Timing: Fifteen minutes upward, depending upon the amount of discussion

Procedure: The organisms of either a fresh or salt water marsh should be selected in advance and their names written on cardboard cards. You will also need scissors and a ball of easy-breaking string, such as kite string.

Ask one student to stand in front of the class so that others can see the card. Through a process of discussion of which organisms eat other organisms, allow others to stand next to those holding cards

Salt Marsh Food Web


Sunlight
(Energy Source)
Marsh Grasses on the Salt Meadow
High Water
Nutrients from the sea are brought in on the incoming tide.
Low Water
Algae on the Mud Flats
Phytoplankton in the Tidal Waters
Marsh Animals (Including Microscopic)
Mollusks
Crustaceans
Decaying plants and animals and salts and minerals from the land wash into the sea on the outgoing tide and become Nutrients (Soluble)
Worms
Shellfish
Nutrients (Solid)
Phytoplankton
Zooplankton

Adapted from the Massachusetts Audubon Society, Lincoln, MA 01773

of organisms they eat or which eat them. These will represent four or five member food chains.

Examples would be:

Diatom → Mayfly Nymph → Sunfish → Great Blue Heron

Detritus → Fiddler Crab → Raccoon → Bacteria

Constructing the web of life will require your knowledge and ability to elicit information from youngsters who might get very excited as they are tied to other organisms. Start with any one marsh critter and ask who eats it or is eaten by it. For every direct relationship connect the two students either by having them hold the end of a length of string you cut or by wrapping the string once around a wrist. Move fast or the critters will become restless. Lead the discussion as you proceed to build a web of many food chains. Some students will have several connected.

You may tug at any one organism to demonstrate how it is connected to all others—directly or indirectly. You may cut a string and ask what could happen to the marsh community if that part of the web was disturbed.

Substantive discussion should probably take place after the web is broken. The discussion could include human attempts to control natural environments, the predator/prey balance in nature, recycling in nature, and the concept of diversity.

Pickle Jar Ponds And Plastic Puddles

Objective: ***To create indoor wet environments for observation and study***

Materials:
- Several large glass jars
- Living plants and animals collected from the pond
- A children's plastic swimming pool

Timing: One class period for establishing the environment, up to several more for observation and study

Procedure for a Pickle Jar Pond: Obtain large glass containers for each small group of students; three students to a jar is a workable number. The lunch program in your school may have two- or three-gallon jars with lids.

Each jar will become its own closed system. Plan for one period of creating the systems with ingredients brought from home by students or perhaps gathered by the class on a field trip. If you use tap water, allow it to dechlorinate for forty-eight hours before you introduce living organisms. It is better to use pond water.

Place a small amount of sand in the bottom of your pickle jar pond. Add rooted aquatic plants such as *Elodea* and floating ones, such as duckweed. Include small animals like snails, small fish, and water insects. Make the jar airtight and place it in a sunny window. The first class could include the use of field guides to identify and learn about the plants and animals being observed. During the first few days, organisms may have to be added or removed to achieve a balanced system. The amount of light may also need to be changed.

You will want to have your students observe carefully and respond to thought-provoking questions based on their observations. You may wish to have each group keep a journal of thoughts, observations, and answers over a period of time. The ponds will last all year.

- How does your closed system differ from ecosystems in nature?
- What food chains do you have in your pond?
- What is the ecological niche of each organism, plant, and animal?
- What niches are occupied by organisms you cannot see? You may wish to introduce microscope use here.
- Study, with field guides and other books, the morphology and physiology of microscopic organisms.
- Write about the flow of energy through your ecosystem.
- Undertake a population count of the macroscopic animals in your pond. Graph the results.

You may wish to have groups undertake experiments such as altering the amount of light available. You may wish to divide your pond into small jars first, so as to provide control on your study. What happens when we tamper with our balanced system?

Procedure for a Plastic Puddle: To create a plastic puddle you will need a small children's swimming pool, preferably of hard plastic form. With the students' help in bringing jars of pond water and pond life to school, create a puddle environment indoors. You'll want the water to fill the pool to a depth of 15 cm or less. Introduce hay, salamander eggs, algae, frog egg masses, aquatic insects, and so on.

This is a good spring activity. You are creating an environment which in nature study is called a vernal pond—a brief seasonal body of water rich in aquatic life.

Allow time each day to observe the pond. Another unit in this series, *Have You Been to the Shore Before?* provides good aquarium observation activities in math, science, language, and art to which you may wish to refer. A hand lens or microscope will open new worlds for observation of detail. Language experience stories could be written by younger children; older ones could write research reports on relationships among organisms now living in their classroom.

A Note on Collection of Live Organisms:

Whether you collect as a class or students collect on their own, it is enormously important for you to instill a conservation ethic. Students should collect only in limited quantities. You may wish to plan so that everyone does not bring in a frog egg mass, for example. Students should also think about humane transportation of living things to school and back to a natural environment in which they can survive.

Creating An Aesthetic Classroom Environment

Objective: ***To establish in your room an environment of aesthetic appreciation of natural beauty***

Materials: • Dependent upon which activities you select

Timing: Variable depending upon your selection of activities

Procedure: A variety of activities are briefly described here. We hope that if one strikes your fancy, you will experiment with it or find a more detailed description of it elsewhere. Sometimes we think that art activities are to be left to the specialist. However, since they are not only rewarding but also can reinforce our other teaching, why leave all the fun to the art teacher?

The activities suggested are, by design, simple and somewhat open-ended. They are good activities for science and social studies teachers for whom aesthetic education may be a new experience.

Provide a variety of choices of activities to your students and provide a wide variety of materials. When we are working with matters of taste and aesthetic appreciation, there are no correct answers. So be open to your students creativity and your own.

Sharpening Powers Of Observation

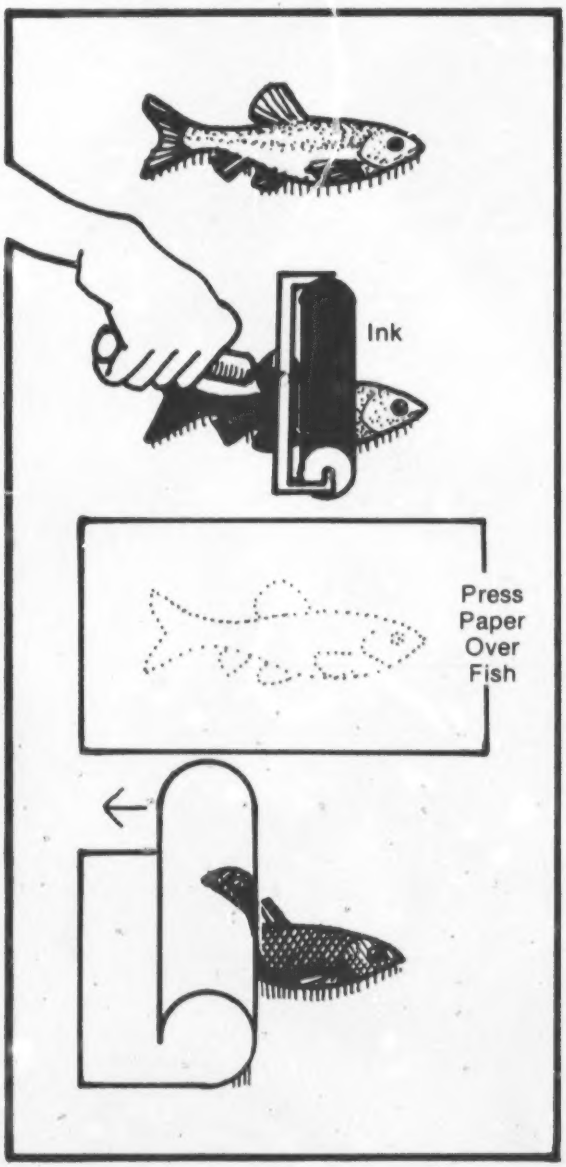
Put a variety of objects from wet environments on a table and have the students observe them knowing that they will be asked to list and describe them. Cover the objects and ask students to write about them.

A Lake Community Mural

Use colored construction paper to cut shapes of fish, lake inhabitants, birds, insects, plants. Have the students paste them on a large sheet of mural paper to depict the lake community.

Fish Printing

Ink a dead fish with black drawing ink. Pelikan Encre De Chine 17 Black works well. This process allows students to copy natural form with aesthetically-satisfying results. Prints may be made on rice paper, cloth, or brown paper toweling.



Fish Printing

Mobiles

Make mobiles using natural objects. Driftwood as balance arms and black thread to hold balancing objects works well. Rocks, beach grass, crab shells, dried plants and other found objects can be gathered. Make space a part of the mobile—more space than objects as there is more water than land in wet environments.

Dried Plants

Mount dried marsh grasses on gray, blue, green, or tan paper to evoke nature's beauty. Leave space to represent water. You may wish to conservatively gather grasses for dried winter arrangements for the classroom.

Wire Butterflies and Moths

Use spool wire or other wire that is easily bent. Shape as desired into moths and butterflies. Wind body, antennae and outline of wings with scrap yarn. Use white glue on a toothpick to secure the yarn. Wind the body and the antennae with yarn. Use white glue to attach colored tissue paper on the underside of the wings.

Framing

When you go on a hike take along empty picture frames students have made of cardboard. Compose pictures in the field by placing the frame over actual material. The purpose of the activity is to see the beauty of natural patterns unorganized by human perception.

Crayon Resist Painting

Use crayon heavily on white (not just light-colored) construction paper. Paint over the entire paper with a thin wash of blue or black paint. Crayoned drawings will resist the paint. This is especially effective for underwater scenes.

Yarn Insects and Fish

Lightly draw a penciled outline of the desired subject on drawing paper. Cover pencil line with white glue. Lay a yarn strand on the glue. Use yarn, markers, colored scraps of construction paper, or crayon to mark the details.

Mosaics

Make mosaic pictures using small rocks and stones of different colors and textures.

Sounds and Smells

"Collect" sounds and smells on a field activity and ask students to recount them in an original essay or poem.

Potato Prints

Carve potatoes cut in half so that bird and mammal footprints are raised from the surface. Print them as they might be observed on the shore of a lake, pond, or stream.

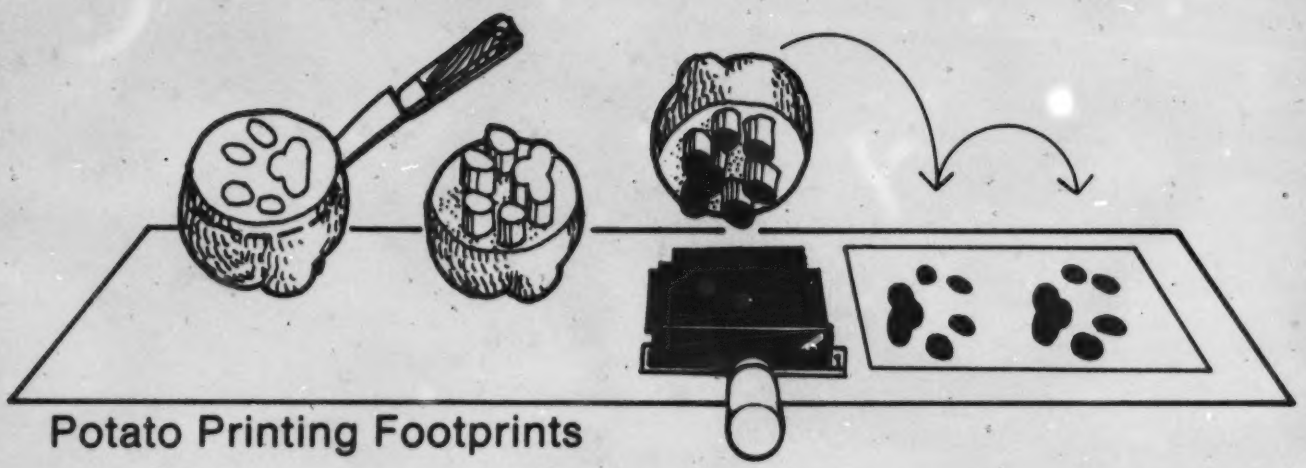
Pressed Plants

Collect, mount, and press seaweed specimens to give the feeling of growing plants. Press several because in nature they are found together. Press and mount marsh grasses also.

Self-Hardening Clay Fish Plaques

Roll clay in a flat sheet one to two cm thick. Draw the desired fish shape on the clay with a pointed stick or pencil. Carefully cut it out with a small knife. Stick a hairpin in top for hanging. Mark fin lines, gills, and the eye lightly with the stick.

Let the clay fish harden for two to three days. Paint them with poster colors if desired, using colored plates from books for authentic markings.



Potato Printing Footprints

The Uses of Plants

Invite a person who can teach dyeing with natural plants, medicinal use of plants, or tell about which wild plants are good to eat. If possible, allow students the opportunity to pursue their special interests as projects.

Stone Insects

Select small smooth stones for insect bodies. Use white glue to attach pieces of pipe cleaner for legs, antennae and other body parts. Glue on small pebbles for protruding eyes. Paint markings as desired using poster paints.

A Slide Show

If the school has a camera, have students take pictures on a field trip. Have them make their own set of slides of marsh or stream life and provide a musical sound track or tape to go with it.

A Feel Box

Make a "feel" box into which students can reach but not see. Change the natural object daily—a feather, a bone, a shelf fungus, a piece of weathered wood.

Natural Clay

Model hand-gathered stream or beach clay into the shapes of organisms such as snails, rocks, and birds.

During the course of your study ask students to leave their creations at school. Let the room become full of diverse student work. Contribute to this aesthetic classroom environment by leaving beautiful objects around—a jar of spring wildflowers, a favorite shell, a piece of driftwood, an unusual stone.

Human History In The Salt Marsh

Objective: ***To develop an appreciation of the value of the salt marsh for people from the early Native Americans to the establishment of the Rachel Carson National Wildlife Refuge***

Materials: •Books by and about Rachel Carson

Timing: Variable depending upon the extent to which you have students pursue background on Rachel Carson and undertake the briefly-described activities.

Teacher-Student Background:

Marshes are both an environmental and historical asset to our states. Prior to the 1600's the Native Americans came to the marshes each spring to harvest the fish and waterfowl. The now extinct Sokokis or Saco tribe utilized the marshes of what is now southern Maine.

European explorers, such as Champlain and Captain John Smith, also visited these areas and were impressed by the resources they found. In the 1600's, permanent colonial settlements were established near the marshes. The area was one of the few places in the state that the settlers were able to hold during the French and Indian Wars.

The early settlers were attracted to these wetlands because they saw that the salt hay was a valuable resource. It was considered the first important agricultural crop in the Northeast during this time. It was this nutritious grass that the colonial farmers used as feed for their livestock. From spring until fall, cattle and sheep were turned loose to graze on the marsh. During the summer, farmers cut and stacked salt hay on racks made of closely packed stakes, called staddles. In winter the cured hay was sledded home by horses wearing special marsh shoes made of oak slabs.

The upland hay used today was called English hay by the colonists. This hay had to be grown with imported species of timothy and clover in order for it to have the nutritional quality of the salt hay. During the seventeenth and eighteenth centuries the seeds of these plants were in short supply and therefore the farmers were dependent on the salt hay from the marshes.

During this time the towns with marsh acreage were considered very wealthy and competition for the resources often led to hard feelings between neighboring settlements. In the early 1700's the Scarborough farmers and the Gorhamites had disputes over who owned the marsh. The Gorhamites claimed that the marshland was a common richness to be shared and the Scarborough farmers claimed it was Scarborough marsh.

Salt marshes quickly lost their economic importance in the early nineteenth century when the seed supplies and improved technology made upland farming more practical. This led to the steady decline in salt farms. At the start of the twentieth century the beaches along the southern coast of Maine were becoming increasingly popular and recreational development was already underway. Railways and seashore trolleys transported thousands of visitors to the Maine coast in the summer months. However, the marshes were ignored for a time by these summer visitors and it was only the clamdiggers and duck hunters that visited these delicate areas.

Around the time of World War II, the marshes became exploited in other ways. As America's population and technology grew, marshlands in our states and elsewhere along the Atlantic coast had to adjust to people's new way of life. The marshes were filled so new roads and developments could be built. The tidal rivers and bays were dredged and widened for the larger ships that were being built. The resulting mud, or spill, from these operations was dumped on the marsh which destroyed the salt hay. Other marsh lands were used for garbage dumps and sprayed with DDT and other nonselective pesticides to control mosquitoes. In these ways humans were degrading one of the most productive ecosystems in the world.

Not until 1960 when the United States had lost one quarter of its original marshlands, did the scientists begin to understand the value of our loss, and to express their dismay to the government and the public. Maine law now requires that any construction planned in or near a wetland be approved by local officials and the state environmental protection agencies.

Maine, with its 20 million acres of land, has less than 17,000 acres of salt marsh, a total area about the size of Sebago Lake. Today about 4,000 acres of marshland in Maine have been set aside as a monument to Rachel Carson—whose books launched the environmental movement.

Rachel Carson is perhaps best known for her book entitled *Silent Spring* (1962). A book that was to change the course of history, it created worldwide awareness of the affects of pesticides and led to the banning of DDT and other dangerous chemicals. Giving Miss Carson's name to the refuge on Maine's southern coast was appropriate for a reason other than her fame as an environmentalist. It was in Maine that she chose to spend her summers from 1946 until her death in 1964. She called her place on the Sheepscot River "my summer home and lab," and there she completed much of the research and writing for two of her books, *The Sea Around Us* (1951) and *The Edge of the Sea* (1955). She also worked on *Silent Spring* here. *Under the Seawind* (1941) and *The Sense of Wonder* (1965) are other books which Rachel Carson wrote. It was her love of the Maine coast that strengthened a fierce deter-

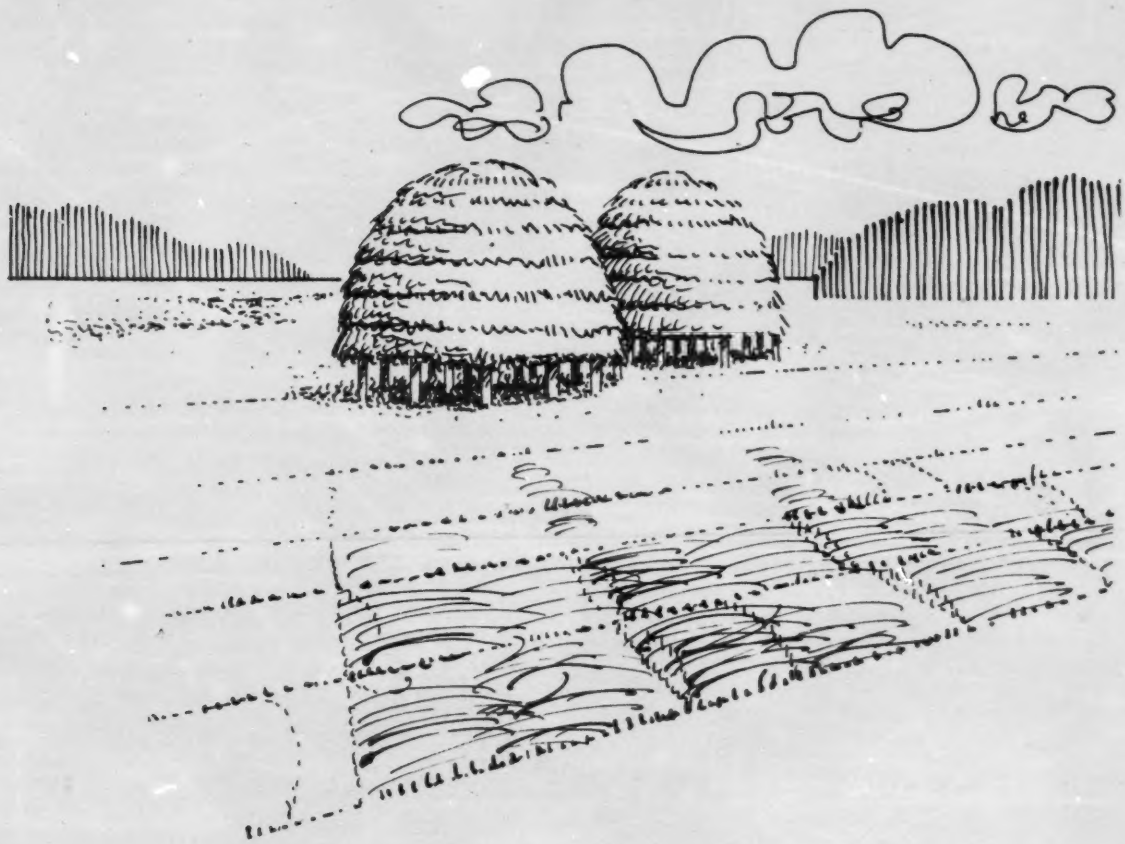
mination to see it preserved. It is fitting that a resource so important and beautiful has been protected and named for her.

Sketches of Activities:

1. Have students write and present a play telling about the role of the marsh in regional history.
2. Have students work in groups or individually on dioramas that depict certain scenes of the marshland's history.
3. Design and build a set of "marsh shoes".
4. Design posters with the theme "Protect Our Marshes" and post them in your school to make more students aware of their importance.
5. Have students write reports on Rachel Carsons' books and on her life. An excellent biography was written by Paul Brooks entitled *The House of Life: Rachel Carson At Work*, Boston: Houghton Mifflin, 1972. An article in the September, 1979 issue of *Downeast Magazine* by Robert Deis is another good resource.
6. Ask your media specialist to set up a display about Rachel Carson in the library.

Further information about the location and wildlife of the refuge, including maps and brochures is available by writing to the Rachel Carson National Wildlife Refuge, Rural Route Two, Box 98, Drakes Island Road, Wells, Maine 04090.

Hay Staddle



A Contest: Doing Your Best

Objective: ***To bring out the best in your students' ability to put to use their knowledge and understanding of wetlands, lakes, ponds, and puddles***

Materials: •Variable

Timing: The suggestions provided here are intended primarily as homework. One or two classes could be utilized for students to share the results of their efforts.

Procedure: Youngsters love contests and they can be a good motivator if properly managed. The contest suggestions given here are but a few of the multitudinous possibilities. Your creativity will provide you with more, and likely, better or more appropriate ideas for your class or school.

How about these?

- An essay contest on the economic value of Northern New England marshes
- A photography contest on lakes or on another specific environment
- An art contest of works inspired by marine environments or creations utilizing marine items, such as driftwood, fish skeletons, dried marsh plants and so on
- A costume contest on marine careers
- A poster contest on the theme of wise use and conservation of resources
- A science fair of projects on wet environments
- A contest of poetry inspired by ponds and streams
- A research contest on the history of a one-time marsh that is no longer a marsh
- A contest to see who can tell the tallest fish tale

Competition can be a difficult issue with younger children, as you know. Contests don't have to have losers. They can be contests with oneself to do one's best with the challenge of the theme, or they can be optional, or they can have all winners!

With older students competition is somewhat keener. This activity can be an opportunity to encourage creativity but without criticism of final results. The interdisciplinary nature of marine education can provide excellent opportunities to learn through contests.

Field Activities

A Note on Field Tripping

Careful planning, well in advance of a field trip, is essential, especially in these days of tight budgets when every opportunity to share the outdoors with our students seems precious. An extensive pre-trip planning activity is included in another unit in this series, *Have You Been to the Shore Before?* It outlines site selection, advance arrangement of necessary items, enlistment of support, preparation for contingencies and emergencies, and thoughts on the teacher's attitude. We recommend that you refer to that activity, if possible. The field trips in this unit are written on the assumption of your advance planning in these areas.

The overall aim of these field trips is to stimulate the interest of students through environmental awareness about their local natural communities and to develop understanding about how these natural communities are part of the total environment.

Stream Exploration

Objectives: ***To explore the stream with all the senses and develop an appreciation of it***

To discover the variety of life forms and their environmental adaptations

To be able to record and communicate observations and feelings about the stream

Field Site: Any nearby stream which has both fast-moving water and small pools. Ideally, the stream would be two to six meters wide and no more than one meter deep.

Materials:

- Personal equipment including boots, waders, and a change of clothing
- White-bottomed pans (refrigerator trays, bleach bottle bottoms, or cardboard milk cartons cut lengthwise work well)
- Hand lenses, tweezers, collection jars with labels, and plastic bags
- Hand screens which can be made with wire mesh of different sizes with wooden handles to attach the wire
- Nets or kitchen strainers for catching and sifting
- Papers, pencils, and writing boards cut from cardboard
- Classroom copies of the stream pre- and post-tests found in the pocket of this guide on page 49.
- Classroom copies of "A Field Guide to Aquatic Insects" found in the pocket of this guide on pages 41-43.

Timing: At least two hours, but this trip could easily be expanded to a full day. Three to five periods of post-trip activities.

Procedure: The teacher background section, *"An Introduction to the Stream"* will familiarize you with the physical nature and human use of the stream. The information which follows will provide further background on plants and animals you may find on your adventure. Insect adaptations and the study of various insect species are especially emphasized because they are commonly found and of great interest to students.

Following the background in this section you will find suggestions for outdoor activities and a list of post-trip suggestions. The pre- and post-test and field guide from the pocket could be copied for student use before, during, and after the field trip, as appropriate.

General Background

The stream is a dynamic, shifting habitat which is subject to far greater changes than larger bodies of water such as lakes. Heavy rains or melting snow can abruptly change a lazy, sparkling stream.

Rock surfaces provide many different habitats for organisms in this community. The upper surface has water flowing over it, the bottom surface has the strata. The rock's front surface receives the full force of the water and is protected on the back or downstream side. Shallow water with a gravelly or sandy bottom provides a very different habitat from that of deep waters with pebbly or rocky bottoms. Fallen logs and plants provide other homes for organisms.

The speed of flow will determine whether the bottom of the stream will be composed of silt, sand, rubble, or bedrock. The nature of this substrate will govern the nature of the vegetation that will grow. For example, larger aquatic plants will grow in silt since their roots must grow down into a substrate. Animal populations are also affected by the nature of the substrate. Plant and animal populations are affected by the speed of the water.

Each stream habitat is unstable and ever-changing. The water flows faster in the spring and early summer. After a flash flood the stream may be transformed from a placid environment into a muddy torrent that washes away many habitats. Drought can destroy habitats also by reducing a

brimming brook to a feeble trickle. Bodies of freshwater with increasing size to deeper and more navigable waters are creek, brook, stream, and river. Eventually streams empty into a larger body of water such as a lake, pond, river, or another stream.

The color of streams changes as they flow from meadow to forest, from open valley to narrow gorge, from a sandy bottom to one of mud or silt. Pure water is colorless; suspended particles in the water impart color to it. Colors of streams reflect the hues and shades of the bottom and the color of the sky, rocks, and trees along the banks. Most of the bottom colors that tinge the waters are due to the plant pigments of mosses, algae, and submerged leafy plants.

Turbulent running water makes oxygen available and keeps the stream's temperature low. The constant turnover of water keeps the temperature uniform from top to bottom. Conditions change along the length of the stream as it progresses from cold, swift-flowing headwaters to warm, slowly-moving, muddy waters of the mouth. These physical conditions alternate in the same stream and we find rapids or ritties with hard and rocky bottoms and pools with muddy bottoms. Organisms found are very different in rapids and in pools.

Life in Streams

Each organism has developed specialized features which enable it to survive in a particular environment or microhabitat of the stream. Organisms adapt to the different types of stream beds and the following is a general description of organisms and their habitats. The most adaptative and diverse environments are those of the gravel and rubble-bottomed streams. These carry an ample supply of food and oxygen to sustain many types of organisms.

Bottom organisms live in, on, or in close association with the stream bed. They will be found as you turn over stones and stir up the mud and vegetation.

Pelagic organisms are those which float or swim freely through the stream. These are the plankton - phytoplankton and zooplankton. The phytoplankton are desmids and diatoms. The zooplankton are protozoans, rotifers, and crustaceans. Very few live in the fast-moving streams but rather in slower silt or mud-bottomed freshwaters.

Surface organisms are insects such as water striders, water beetles, and plants such as duckweed. They float or glide along the surface water tension.

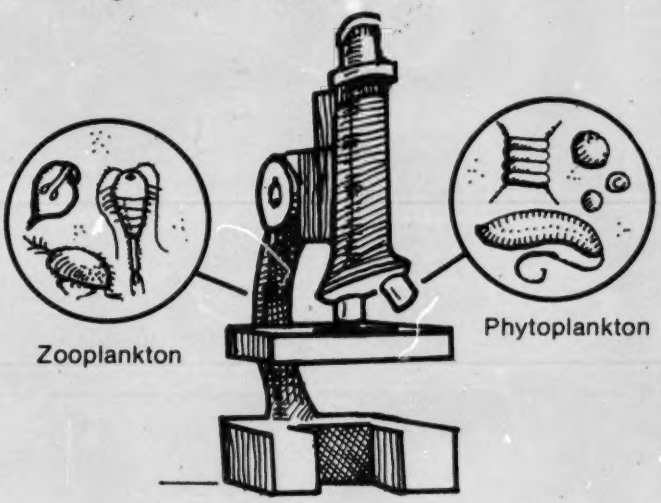
Plants

Plants are the producers of the stream environment as they are the basic food source for many animals. They appear on the slimy surfaces of rocks, floating on the surface, or attached to other types of substrate. The food crop of the stream is largely blue-green algae and some species of diatoms. Diatoms and blue-green algae are usually unicellular but occasionally colonial or filamentous. Diatoms have a unique silica shell, and are usually yellow brown in color. Primitive algae which are related to bacteria, are often microscopic green plants which have no roots, stems or leaves.

Mountain brooks and fast-moving streams have a species of water hypnum. The stems are quite durable and will not easily break off in the current. Other rooted aquatic plants are called macrophytes and include some types which are always submerged such as *Elodea* which is weakly rooted in the gravel of slower moving streams. The dark, green, translucent leaves are arranged in whorls around the stem. Populations of *Elodea* have the ability to transform the stream to a slower moving muddy stream because of their ability to reproduce rapidly.

Some other macrophytes float, such as duckweed, water hyacinths, and water lilies. Water lilies are rooted by flexible stems which lower and raise the leaves. The leaves of water plants have many intercellular spaces within the plant tissue which allow for greater buoyancy. There are not too many types of rooted plants in streams due to the nature of stream beds and the velocity of the water flow. Other examples of rooted plants are water crawfoot, pondweed, and water cress.

The emergent plants along the banks are also important in the stream community. They provide animal habitats and increase the amount of organic matter in the stream. This affects productivity as well as the oxygen content. These plants affect the erosion of the slopes surrounding the stream and change the stream sediment load.



Animals

Microscopic animals may live in the open water, on the bottom, or attached to the stems of aquatic plants. They may be unicellular or multicellular. Most are motile. There are fewer microscopic animals in streams than in ponds. Most common are worms and protozoans. Vorticella is a very common protozoan. Worms cling to rocks and live on the gravel bottoms.

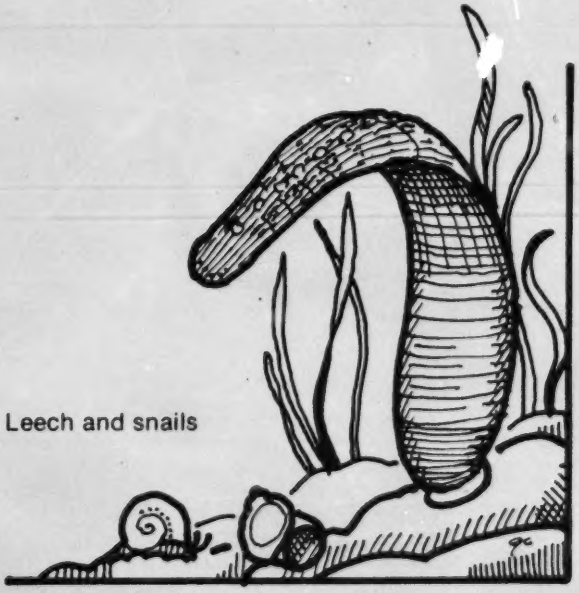
Sponges and bryozoans are also found if you turn over rocks. A sponge is a skeleton of silica surrounded by a mass of living material. Flagella are present around many pores and channels throughout the structure. By their waving action, the flagella move water and food in and out. Bryozoans, similar in appearance to moss, are a colony of individuals living in close association. The animals are hidden under their observable outer skeletons and, when undisturbed, move out their tentacles to secure food.

Invertebrates such as clams, snails, and leeches are also common. An arthropod which is famous for its adaptability and is not an insect is the crawdad or crayfish. With its strong walking legs, powerful tail, and huge grasping claws, the crayfish can withstand a strong current. There is an abundance of food for the crayfish in the stony stream bed. This is an important member of the stream community which eats practically everything, both plant and animal. Turtles, birds, and mammals prey on the crayfish.

The largest and most popular of the stream animals are the fish. These are the only vertebrates that live directly in the water.

Trout are abundant in fast streams. They hide in the shade of overhanging logs and branches waiting for a fly to fall in the water or for a worm or insect to come into their paths. Trout and salmon are part of the same family of fish. They have an identification mark in common—a small, fleshy adipose fin on the dorsal surface of the body opposite the anal fin. Trout are usually restricted to fresh water but a few migrate between fresh water and the ocean for spawning. Salmon spend most of their adult life in the ocean returning to the fresh water to spawn where hatched. There the salmon also die. Brook and lake trout use gravel beds of their home lakes for spawning. The eggs are covered by gravel to escape predators.

Several species of minnows may also be found.



Leech and snails

Shiners develop tiny horns on their heads which are characteristic of the males during mating season. The black-nosed dace can be identified by a black band down each side of the body. The stickleback is easily identified by its dorsal spikes.

These are only some of the fish which may be found in streams. In muddy streams, suckers, northern pikes, catifsh, and yellow perch can also be found.

Insects belong to a large animal classification called the arthropods, or joint-footed animals. The characteristics of arthropods are segmented bodies, exoskeletons, jointed legs, separate sexes, and complete digestive tracts with mouth and anus. Common characteristics of all insects are three main body parts (head, thorax, and abdomen), six legs, antennae and tracheal tubes for breathing found in adults. Aquatic forms have gills, though, in their immature forms. Many of the characteristics may be seen with the naked eye but many others will be observable only with the use of the microscope. This is true especially when looking at the eyes and the mouthparts.

Adaptability of the insect can be seen by comparison of the larval and adult forms of the same species. All insects follow similar patterns of growth along the two specific cycles. Metamorphosis is the process whereby a creeping wingless larvae transforms into an adult. The cycle may be as follows—egg to larva to pupa to adult. There are cycles without the pupal stage in which the adult is a larger replica of the immature form. Insects molt, which means that they lose their outer skeleton as they grow to the next stage of the cycle. Almost all the water insects follow the cycle without the pupa.

Insects which inhabit streams must be well-adapted to the physical and chemical nature of such environments if they are to survive. Variations in life cycle or developmental periods enable most groups to cope with the temperature regimes found in streams. Other stream parameters seem to be of less importance in effecting observable changes in aquatic species. The most significant characteristic of the stream environment affecting living organisms is current. Stream insects exhibit a multitude of anatomical and behavioral adaptations in life in flowing water.

Flattening of the body allows the insect to live in the boundary layer, the thin layer of water surrounding rocks and other objects in which current velocity is reduced considerably by friction. Very small insects can exist in the boundary layer without any marked flattening but this adaptation is quite important for some mayfly and stonefly nymphs. Flattened insects are also able to conceal themselves under stones, a protective measure against predators.

Streamlining allows the insect to approach a fusiform or tapering shape which is the shape most efficient in reducing resistance to current. This adaptation is shown by some mayfly nymphs which move about quite freely in the current.

Hydraulic suckers are exhibited by the highly-specialized larvae of one fly group. The suckers

Metamorphosis of Typical Aquatic Insect

allow the insect to remain attached to rocks and other objects despite strong currents. Movement is allowed by releasing and reattaching the suckers in sequence.

Increasing the area contacting the substrate can increase the frictional resistance and make the organism less likely to be swept off in the current. Some insects have certain parts of the body flattened on the underside. These areas, which often have a fringe of hairs, are called friction pads. Water pennies, a group of beetle larvae, are flattened on the underside and have an outer ring of flexible plates which press tightly against rock surfaces.

Hooks and grapples are found on various parts of the body in many aquatic insects, usually at the end of the abdomen or on legs or leglike structures. Some are used to grasp roughnesses on rock surfaces; others attach to mats of silk secreted by the insect on various surfaces. In this way, the insect is able to hold on—even in rapid currents.

Quite a number of insects attach themselves or their shelters to rocks or other objects with silk or some type of sticky secretion. This phenomenon is best exhibited in certain caddisfly and fly larvae. Such attachments may be temporary or permanent.

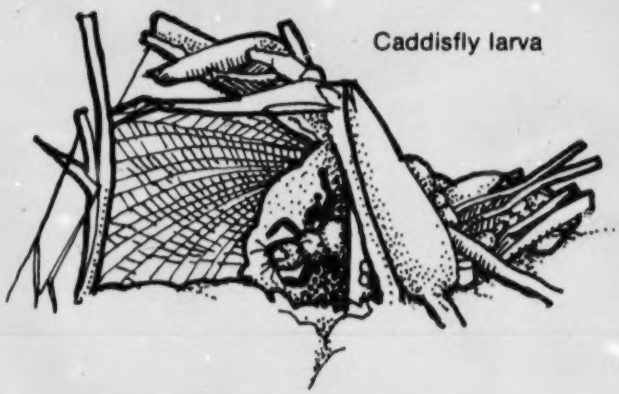
A number of caddisfly larvae use stones or larger sand grains in the construction of their houses. These heavier particles act as ballast, making the insect and its shelter less likely to be swept away in fast water. The heavier objects may also be positioned in such a way as to maintain proper orientation of the insect in the current.

A number of aquatic insects possess body spines in addition to hook-like claws on the legs. These projections allow such animals to fix themselves among mosses and other plants where current is often substantially reduced.

Besides possessing a wide range of morphological adaptations to the stream habitat, aquatic insects have also evolved successful behavioral adaptations. Burrowing is a common behavior exhibited by animals in response to current—a behavior facilitated by long narrow bodies. The hairs prevent the surrounding particles from completely covering the insect, thus allowing space for oxygenated water to flow over the body. A behavior somewhat analagous to burrowing is movement into crevices between and under rocks. Some insects show a light-avoidance behavior which favors such shelter. In either case, insects are able to avoid extreme current.

There is some evidence to suggest that insects may select certain current conditions in accordance with their abilities to resist dislodgement and also find food and obtain sufficient oxygen. Such behavior may change with the growth and development of the insects.

Despite the preceding morphological and behavioral adaptations, most aquatic insect populations are subjected to downstream displacement, or drift. This may be compensated for by upstream movement by aquatic forms, but in most cases this behavior is thought to be exhibited by the flying adult forms. These adults tend to move to the upper reaches of streams before depositing eggs. If it were not for such compensatory upstream movements, rapid-current areas of streams would be devoid of insect life.



At the Stream

First, examine with the whole group the stream and the area surrounding it in the general sense. Note the types of plants along the stream and the amount of sunlight which reaches the water. Point out riffle and pool areas. Discuss the structure of the stream and talk briefly about stream temperature and water chemistry. Have students each make a sketch map of the stream. Stand back from the section of the stream under study and draw its general shape. Indicate where it widens, narrows, or curves. Show, if possible where the old meanders were. Include the position of major features like fallen trees, emergent plants, exposed rocks, bridges, and so on. Label any other features that can be easily seen from the shore, such as rapids, shallow sections, pools or bottom conditions.

Their sketch maps might show:

river course, width, and flow
shallow and deep sections
river bed conditions (sand, clay, gravel, boulders)
eddies in the stream flow
bank conditions (slope, composition, undercutting, and so on)
river obstructions
extent of the flood plain

Have students use their senses to explore the stream environment. Allow the students to get into the water if they have the proper gear and clothing. Walk around the stream feeling the stream bed or the surface of rocks to feel the plant growth, the weathering of the rocks, and organic litter.

Students may then work in small groups to collect insects which could be brought back and placed in the white bottom pans for group observation. Each group could record the types of organisms it finds, the locations in which they find them, and the approximate count of populations. They should be encouraged to draw the insects, as this will sharpen their observations. Have them find examples of the various adaptations. Then, have them use "The Field Guide to the Aquatic Insects" in the pocket of this unit to learn more about individual species.

As insects are collected, have students examine them with lenses. Find gills, wing pads, and other structures. Find adaptations. Be certain to have them return rocks and other objects to their original locations. Ask them to release living organisms to the stream upon completion of their observations.

Later, you might have students select an individual spot within earshot where they will have fifteen minutes alone to sit silently and observe with several senses. Then record their observations and feelings.

Using one's senses is very adaptable and many ideas can be followed depending on the age level and size of the group. This can be a time of creativity and personal reflection serving as a break in the more organized activities.

Post-Trip Activities

1. Invite a conservation professional from your local area to speak to your class about the local streams—their problems and management.
2. Prepare posters of the food chains/food webs of the stream environment and research these differences from other fresh water environments, such as a river or pond.
3. Study a pond, river, wooded area, or field and undertake a comparison of the animal and plant species using the proper methods of collection of data and samples.
4. Make a booklet of the information learned by each student during the study of the stream environment. Have each student do his or her own writing, describing and illustrating. Gather these to make the booklet. The students should work on the design and the booklet may be shared with other classes at your school. Maybe your class could do a presentation of the things they learned and enjoyed about the outdoor activity.
5. Draw a large mural of the total interacting stream environment with its physical surroundings and its organisms. Display it in an area of the school where many other classes will see it.
6. Assign students to a specific research project using classroom or library resources.
7. Write a poem describing the outdoor experience.
8. Do part of a unit or a special lesson on the environmental laws regulating the use of fresh water areas.
9. Debate the development of an area for housing in your town versus keeping it as the natural area of woods and stream. Have students represent the interests of groups of developers, conservationists, the local people and decision-makers.
10. Do a microscopic study of the samples collected. This will require a compound microscope with high power lenses. Most schools will have dissecting microscopes but a high power one may have to be borrowed.
11. Do a study of rocks found along the stream. Look for fossils and also classify the rocks.

Saltwater Marsh Study

Objective: ***To study the physical characteristics and biological organisms of the saltwater marsh***

Field Site: Any saltwater marsh

Materials: This list is rather large. It represents equipment that could be used for a wide variety of activities depending on the age and background of the group. After determining which aspects of the study you wish to undertake, scale the materials down accordingly.

- Camera
- Thermometers
- Hydrometer
- Rules and meter stick
- Clipboards and pencils
- Seine or crabnet
- Corer
- Plankton net

- Shovel, trowels, or clamrake and buckets
- Sieves (½" and ¼" rabbit wire screen, a window screen, a kitchen sieve)
- White enamel pans
- Binoculars
- Collecting vials or baggies and rubber bands
- A stop watch
- A map or chart of the area
- Crayons or water colors
- Sneakers or rubber boots
- Thread and string
- Wooden floats
- Hand lenses
- pH paper
- forceps or tweezers
- medicine dropper
- Identification guide books and field guides
- Three marker poles, one to two meters long
- Knife

Timing: This activity will take several hours and would best be planned so that the tide is at slack low at the time of your arrival.

Procedure:

Part One: When you arrive, set up a series of marker poles about thirty meters apart along the side of the creek as it twists and turns its way toward the uplands. It may take a little time, but try to find a branch of the creek that reaches well inland. Number the points—one, two, and three. Divide up your group and have them do the following:

1. Take a temperature reading of the water. Read at the grass surface on the edge of a bank and about waist high when standing in the grass.
2. Determine salinity. As in all water studies, it may be well to collect a bottle of water for these tests.
3. Determine the velocity of the water. Use wooden floats and a stop watch.
4. Take a pH reading.
5. Take a plankton sample. Simply throw the net in and walk it against the current.
6. Describe the color of the water. Hold a sample against a white background.
7. Carefully collect samples of fish, provided you have proper equipment.
8. At each site, record the plant life. Note size of the plant, its abundance and its location with respect to the creek.
9. Take pictures of the area and close-ups of specific materials. Sketch specific materials also.
10. Carefully look around on the grass and expose soil for signs of life. Ruffle up the grass, and examine these sites carefully. Describe the animals found and note where you found them. Are they in great abundance? Return the soil and grass to its undisturbed condition as much as possible.
11. If you have a corer, take a core sample from the site. Describe soil texture.

Part Two: At low tide, gather the group back at the mouth of the inlet. Proceed up the creek stopping at every stake and do the following (subject to the available equipment):

1. Observe and describe the bank profile. Dig into the bank and record its height from creek bed to upper surface.
2. Is there any life or evidence of it in the creek bank? Carefully collect individual

samples. Record their abundance and location.

3. Describe the bottom of the tidal creek. Feel and smell the sediment. What kind of sediment is it? Can you classify it as to sand, silt, or clay?
4. Is there any life or evidence of it on the surface of the creek? Carefully collect small samples. Record their abundance and location.
5. Take some surface material in a jar with some water. Examine it later for microscopic life and describe what the animals are doing and what they are eating.
6. Do the same with the sediment. Try this fifteen centimeters down.
7. Are there any invertebrates in the sediment? Dig in areas where you see holes. Use the sieve and sorting pans.
8. Use the camera to get close-ups of life.
9. If you have the facilities, you may want to bring back some organisms for studies.

Part Three: With the tide on the way in, go back to the sites to which you were assigned upon arrival and repeat the following:

1. Temperature readings.
2. Salinity determination.
3. pH reading.
4. Plankton sample.
5. If netting is available, try to capture some fish.
6. Describe color of water.
7. Velocity of the water.
8. Record any of the observations indicating differences between Part One and Part Three.

Follow-up in the Field or in the Classroom

1. Make a food web using the plants and animals you saw in the marsh. This is described in "A Marsh Food Web Activity" on page 12.
2. Discuss how organisms adapt to life in a salt marsh and in brackish waters?
3. Discuss if anyone saw evidence of pollution.
4. Ask what protects the marsh from the sea.
5. Seek student opinions about these two questions: What is economically important about salt water marshes? What is aesthetically important about salt water marshes?
6. Ask what mammals make use of the marsh. Did you observe evidence of their presence?
7. Using paper sheets, record data and group observations. Use one sheet for each testing point.
8. Discuss the tidal effect on the marsh. Are there times when the whole marsh is covered? How often? Were there any differences between the tests done as the tide was going out and when it was returning?

The Great Local Lake Adventure

"A lake is the landscape's most beautiful and expressive feature. It is earth's eye; looking into which the beholder measures the depth of his own nature."

Henry David Thoreau

Objective: ***To appreciate the values of a lake—aesthetic, economic, historical, and natural***

Field Site: The region surrounding a local lake or lakes which students have studied

Materials:
- Pencils
- Scavenger hunt papers
- Post-trip quizzes
- Lunches
- Chaperones
- Hand lenses
- White-bottom containers
- Dip nets
- Appropriate clothing and foot gear
- Field guides and nature books
- Binoculars, if available

Timing: One school day—for as long as you can have the bus

This activity will need to be developed according to the lake or lakes region you select to study. The teacher background information, *An Introduction to Lakes and Ponds* on page 6 will help you to choose topics for your unit. The worksheets included here are examples for teaching about the Sebago Lake area of Maine.

Procedure: This activity is intended to be an adventure in discovering not only the beauty of a nearby lake, but its natural and human history, as well as its importance to people. To undertake an all-day trip with stops of interest will require considerable planning on your part. Why not work with another interested teacher? This will share the work and fill the school bus.

The field trip should be organized to follow several classes of learning about lakes at school. Students should have background in several topical areas of lake study at their grade level. The trip could include stops to reinforce the topics studied. For example, if you have taught about management of the sport fishery resource, perhaps you could stop at a fish hatchery. If you have

discussed water quality, perhaps an official responsible for the public water supply could meet you.

The following list is meant to suggest some *possible* stops on your adventure:

- A rendezvous with a fisheries biologist or a game warden from the state government to discuss natural resources management and conservation.
- A girls' or boys' summer camp, a public campground, or marina to discuss the lake's economic value with the owner.
- Sites of historical interest in Native American or white history or Legend. Such a stop could be enlivened by meeting with a senior citizen who knows the lake's stories and secrets.
- A state park on the lake—even better if someone on the staff can answer questions for your students.
- A picnic spot for eating and exercise.
- Your field trip should include a vista view over the lake if such a spot exists, preferably at the beginning or the end of your trip.
- A carefully chosen spot for field work with plenty of time for discovery and observation activities. Perhaps one of the youngster's parents owns a camp on the lakeshore which you could use. Arrangements might be possible with a children's summer camp which is not in session.

You may want to develop a scavenger hunt paper and post-trip quiz to make travel time worthwhile. These were developed for younger students at the George C. Soule School in Freeport, Maine. You could write them appropriate to your students' level and to fit your lake's characteristics.

Name _____

The Great Sebago Adventure Scavenger Hunt

Look for these things and check them off or write them down as you find them:

___ North Windham town line. You're in lake country! (one point)

___ See if you can find a "worms" or "worms for sale" sign; you may not answer this question unless you find one. Why are they selling worms?

_____

_____ (one point)

___ You get one point each for any ponds or lakes in lake country you can name. You must find the name on a sign.

_____

_____

___ Write the official name of the fish hatchery.

_____(one point, if correct)

___ Why is this called Quaker Ridge? _____

_____ (three points)

One point each for the following examples of human history. ___Civil War Monument
___ Old Stone Wall ___ Old Schoolhouse
___ Iron Bridge ___ Cemetery ___ Wagon ___Wheel

___ Find a tree farm sign or more if you can. (Maximum - three points)

___ Farming is important in the Lake Country. (one point each)

___Horse Farm ___ Apple-Cider stand
___Vegetable Garden ___ Cow

___ One point for each species of farm or wild animal that you see. _____

_____

___ One point for each of these you can find.

___summer theater ___ a gift shop
___a picnic area ___ a gull
___an iron bridge ___ a bog
___a white birch tree ___ a restaurant
___a weathervane ___ a beach
___a marina ___ a brook
___an inn ___ a boat
___ a glacial erratic

___ How many great ponds in Maine? _____

_____(two points)

___ Name jobs that depend on the lake.

_____

_____ (one point each)

___ What does "draw" mean on the draw bridge sign?

_____(two points)

___ How long was the canal system between Portland and Harrison?

_____ (one point)

___ What did the canal boats carry? _____

_____ (one point each)

___ List three natural (not made by people) things you saw at the Sebago Lake State Park.

_____

_____ (one point each)

___ Name as many towns as you can which you were in today.

_____

_____

_____ (one point each)

Land of the Lakes
Post-Trip Quiz

1. What is the highest hill in the Sebago Lake region?
2. From which direction did the glacier come?
3. Can you name two species of fish that live in Sebago Lake?
4. Name as many things as you can that you saw from the top of the tower.
5. Sebago Lake is the largest ___, second largest ___, third largest lake in Maine ___.
6. Why was the canal built?
7. Why do we have State Parks?
8. Why is swimming not allowed in the Portland Water District intake zone of the lake?

9. How deep is Sebago?
10. What does "Sebago" mean to Native Americans?
11. Are there any islands in Sebago Lake?
12. How were the lakes in this area formed?
13. Is Sebago Lake big enough to be a Great Pond?
14. Why is it important for Sebago Lake to be clean?
15. What other state can you see from Douglas Hill?
16. Who owns Douglas Hill?
17. What does the writing on the rock mean at the top of Douglas Hill?
18. Who was Nathaniel Hawthorne?
19. Name five lakeshore plants.
20. Who are the Shakers?

The School-Site Watershed: Puddle Study

Objective: ***To investigate the flow of water on the school grounds as related to the larger concept of the watershed.***

Field Site: The immediate environment of the school

Materials:
- Pencils
- Paper
- Clipboards, made from cardboard with an elastic band and possibly a plastic bag to protect it from the rain

Timing: One to three class periods

Procedure: After introducing the watershed concept, explore the school site and discuss drainage of rainfall from the school grounds. Have small groups list sites where water is drained. Include all drain pipes, gutters, gullies, storm drains, streams, culverts, and ditches. This could lead to several mapping activities. On a rainy day, students could plot actual flow.

Where are the puddles found? These puddles could be explored in a variety of ways. Measure their depth, width, and area. What living things can you find in them with your eyes? With a hand lens? With a microscope? Measure the pH. Is this acid rain? Compare a puddle on the pavement with a puddle on the soil. Is there any difference in signs of life? What effects does water have on the site? Ask students to list signs of weathering and erosion. Are human systems of drainage working? Should students engage in problem-solving at this point?

You may want to obtain a topographic map which contains your school to use with your class in identifying wetland areas and outlining small watersheds. These maps may be purchased from Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington Virginia 22202 - as well as from many local dealers, such as bookstores.

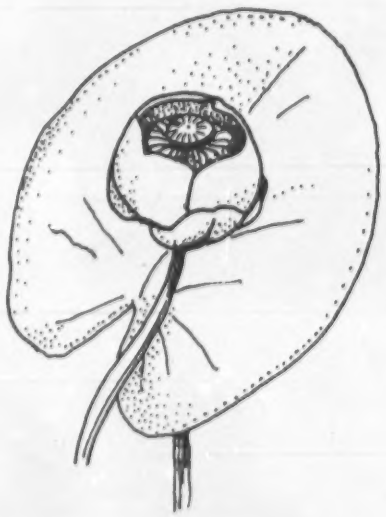
You might wish to teach a lesson in reading and interpretation of map symbols. It could be a lesson in math by discussing heights and depths with the use of the contour lines. A compass is valuable for learning about maps and seeing how useful they can be. The compass is, in itself, a good way to discuss direction and basic geometry skills.

Use the map to locate the watershed of the school from the slopes, hills, and mountains of the area which drain down into it. There is no need to go into great detail of how the contour lines actually determine the drainage area of the stream. Just give your students a basic idea of how it can be determined from the map.

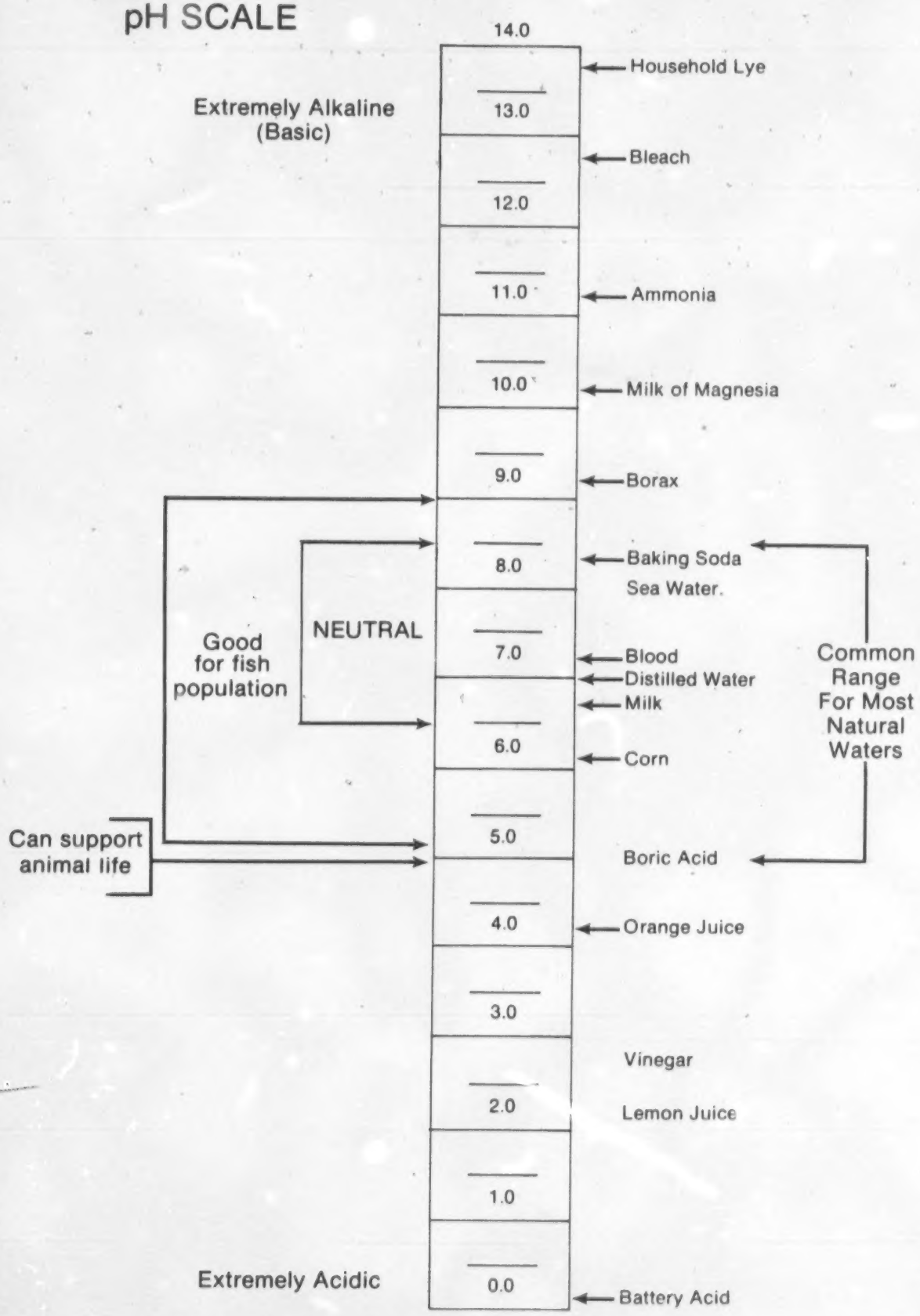
Most likely, students will find many wetland areas on your local topographic map. In this way you can give your students a sense of how water-rich our region is. This understanding should be balanced with an understanding of the fragile nature of water quality.

From this point you may wish to extend the discussion to use and conservation of water in the school and in their homes. One possible activity is to have each child bring to school an empty one gallon plastic jug. This would be filled at school and students would try to use just that much water until the next day. This involves carrying it on the bus and using only that water at home for drinking, washing, cooking, and other consumptive activities.

Water shortages are perhaps the preeminent conservation problem of our time. This activity develops an appreciation of the precious nature of the resource.



pH SCALE


14.0
Household Lye
Extremely Alkaline
(Basic)
13.0
Bleach
12.0
11.0
Ammonia
10.0
Milk of Magnesia
9.0
Borax
8.0
Baking Soda
Sea Water.
NEUTRAL
Good
for fish
population
7.0
Blood
Distilled Water
Milk
6.0
Corn
Common
Range
For Most
Natural
Waters
Can support
animal life
5.0
Boric Acid
4.0
Orange Juice
3.0
Vinegar
2.0
Lemon Juice
1.0
Extremely Acidic
0.0
Battery Acid

Teacher Resources

Organizational Resources

Another unit in this series, *Have You Been to the Shore Before? A Marine Education Infusion Unit on Seashore and Aquarium Life*, contains an extensive listing of organizational resources. Many of those same agencies and groups could be of assistance on the topics in this unit. You may wish to consult that list if it is available to you. This abbreviated list contains primarily those organizations *not* included there.

Society for the Protection of New Hampshire Forests
Cleve Kapala, Education Director of Programs and Policy
53 Portsmouth Street
Concord, New Hampshire 03301
Telephone: (603) 224-9945
The society is a private, non-profit conservation organization founded in 1901. Its resources include teenage and teachers' conservation camps, interpretive centers and self-guiding nature trails, a Day Laboratory program for elementary school children, an environmental education consultant for schools, and information on land protection and forest management.

Water Supply and Pollution Control Commission
Terrence Frost, Chief Aquatic Biologist or Ronald Towne, Chief Water Pollution Biologist
Post Office Box 95
Concord, New Hampshire 03301
Telephone: (603) 271-3503
The commission can answer teachers' queries and will sometimes be able to provide speakers on the topics of water quality.

New Hampshire Department of Fish & Game Education Division
Bridge Street
Concord, New Hampshire 03301
Telephone: (603) 271-3421
The department can provide print material for teachers. Write or call for details.

The Audubon Society of New Hampshire
Carol E. Smith, Education Director
3 Silk Farm Road
Concord, New Hampshire 03301
Telephone: (603) 224-9909
The Audubon Society can provide children's books and reference materials through their library in Concord. A fine film of sixth graders on a field trip to the marsh is available also. It is twelve minutes long and entitled *Me and My Wetlands.*

Water Resources Research Center
Gordon Byers, Chairperson
108 Pettee Hall
University of New Hampshire
Durham, New Hampshire 03824
Telephone: (603) 862-2144
This organization would best be utilized for teacher background information on the technical aspects of water quality.

State of Maine Department of Inland Fisheries and Wildlife
Tom Scheiner, Information and Education Specialist
284 State Street
Augusta, Maine 04333
Telephone: (207) 289-2871
The Department can provide a variety of materials prepared for the general public but appropriate for your students' level. Pamphlets and magazine article reprints are listed in their free publications catalog. The titles are broad-ranging, the content worthwhile; a sampling, "Two Water Bugs", "The Swampland Singers—Maine's Frogs", "Food Interrelationships of Salmon, Trout, Alewives, and Smelt in a Maine Lake", "Maine's Rivers: The Aroostook " and many dozens more. Prices vary from ten cents up and a price list will be sent with the catalog. The Department's magazine, *Maine Fish and Wildlife*, is excellent. For lake study, surveys of hundreds of Maine lakes exist—twenty cents each—less on volume orders. These resources can be used for student reports or ordered in class size quantities for reading material. Very highly recommended.

Congress of Lakes Association
c/o Natural Resources Council of Maine
Marie Wooster, President
271 State Street
Augusta, Maine 04330
COLA is a statewide organization dedicated to educational, legislative, and research efforts in behalf of Maine lakes. Some slide presentations and print materials are available. This group could also put you in touch with any one of the dozens of local lake associations that might help you study a lake or pond in your community. We recommend a booklet they publish, *For The Sake of Your Lake: An Action Plan for Lake Associations.*
This is a volunteer organization which operates from the offices of MCM; a written request is more likely to receive attention than a telephone call.

State of Maine Department of Environmental Protection
Information and Education Division
Bureau of Land Quality Control
State House Station 17
Augusta, Maine 04333
Telephone: (800) 452-1942
The DEP publishes informative well-written brochures which would be of great value in planning your unit. Especially good are "Protecting *Your* Lake: A Citizen's Guide to the Great Ponds Act", "Cleaning Up the Water: Private Sewage Disposal in Maine", "Coastal Wetlands", and an eight-pamphlet set "DEP and You." Some of these are available in classroom quantities; others could be used in your resource files for student projects. The department also has slide shows and materials on the timely concerns of acid rain and hazardous wastes. Their publications also list addresses and telephone numbers of other sources of help and information, including the Land Use Regulation Commission and the State Planning Office. An important resource, highly recommended.

Maine Audubon Society
June LaCombe, Director of Environmental Education and Natural History
Gilsland Farm
118 Old Route One
Falmouth, Maine 04105
Telephone: (207) 781-2330
Many resources are available through Maine's largest environmental organization; contact June LaCombe for assistance. Especially noteworthy is the Scarboro Marsh Nature Center which provides nature hikes and exhibits for classes visiting Maine's largest marsh.

Resource Persons

There are many persons upon whose interest and experience you might be able to call in teaching this unit. They are likely to be in your town or a nearby one. Be creative in thinking of others. Visits need not be lengthy and it might be well to ask visitors if they would be willing to be on a panel with a small number of others.

An experienced birdwatcher
A planning board member
A professional or amateur naturalist
The sewerage treatment plant operator
A person with many years of sport or commercial fishing experience
A marine worm digger
A fish broker
A trapper of beaver or muskrat
A warden from the Maine Department of Inland Fish and Wildlife or the New Hampshire Department of Fish and Game
A tidal power advocate
A real estate developer
A park or amateur naturalist
A peat bog harvester
A lobsterman
A member of the local conservation commission
A senior citizen who has known the area throughout life

Teaching Units Related To Wet Environments

There are several other units on wetlands available; three of the best are listed below.

Understanding Wetlands is planned for use with upper elementary grades through adults. It describes Michigan's fresh water wetland environments with special attention to benefits to people. The kit includes a seven-frame filmstrip, cassette tape, student and teacher manuals and thirteen posters in color. The complete package is available for $14.75 from the Michigan Department of Natural Resources, Information Center, Box 30028, Lansing, Michigan 48909.

The **Outdoor Biology Instructional Strategies (OBIS)** series has several excellent units related to the study of water. If you are interested in activity-centered science teaching or outdoor environmental education, you would appreciate OBIS. The teacher materials are cards describing the materials, preparation, and action to carry out the activity. They are designed for your students' age group, utilize inexpensive materials, and have been extensively field-tested. They may be ordered from Delta Education, Box M, Nashua, New Hampshire 03061. OBIS teacher workshops may be arranged through Dr. John W. Butzow, Shibles Hall, College of Education, University of Maine, Orono, Maine 04469. Activity cards recommended to go with this unit are:

Waterholes to Mini-Ponds
Water Breathers
What Lives Here? Life in the Water
Habitats of the Pond
Water Striders
Animal Movement in the Water

The twenty-page *OBIS Pond Guide* to common plants and animals is also recommended.

The National Wildlife Federation is developing an environmental education program called *The Class Project* which contains a unit for grades six through nine called *Wetlands Management*. It will be available by the end of 1981 from NWF, 1412 16th Street, N.W., Washington, D.C. 20036. The teacher background information is good and the investigations are well-planned and clear. They involve a diversity of activities and allow for a variety of teaching and learning styles. We recommend this unit enthusiastically.

Two Very Special Books For Teachers

Our annotated bibliography includes a listing of what we feel are the best books for teachers related to wetlands. Here we list two very special books about exploring nature with youngsters. These are books which can change your way of teaching, and even your whole way of experiencing nature.

We hope that you will read them and try the ideas. They capture a philosophy of nature study used by naturalists for many years which relies upon a closeness to natural objects and processes, an openness to students, and an attitude of appreciation of nature. They express this philosophy beautifully and translate it to lively and significant outdoor experiences.

Cornell, Joseph Bharat. *Sharing Nature With Children: A Parents' and Teachers' Nature-Awareness Guidebook.* Nevada City, California: Ananda Publications, 1979.

Contains top-notch tips for teachers, unusual and fun activities, and great games.

Van Matre, Steve. *Acclimatization: A Sensory and Conceptual Approach to Ecological Involvement.* Martinsville, Indiana: American Camping Association, 1972.

Contains strong philosophical statements. Also, it has superb activities for a fresh-water marsh, a lakeshore, and a bog as well as dandy gimmicks and ideas.

A Note On Places To Visit

In the other marine education infusion units in this series the specifics of particularly fine places to visit are given. The wet environments included in this unit are so extensive and—in our water-rich piece of the earth —so common that we have not done so here.

If you are fortunate to teach school near a major well-known government land holding such as the Moosehorn National Wildlife Refuge or the Rachel Carson National Wildlife Refuge—take advantage of it. If you live near a major private individual or organizational holding, such as the Crystal Bog or the Scarborough Marsh Nature Center—try to visit it. Or if you have the advantage of being near an unusually fine area for exploration which doesn't have organized ownership or protection such as the Bangor Bog or the Merrymeeting Bay area—by all means, use them if you can.

It is important to emphasize, however, that visiting this kind of major area is not necessary. Maine's wet environments are so numerous that you may find you'll have much better adventures close to home.

This unit is based on the simple idea that the immediate environment is not only of great interest to the child but that it is worthy of study and appreciation. Very, very few places in the bi-state region are deprived of wetlands, lakes, and ponds. None are deprived of streams and puddles. We encourage you to help your students become aware of local wet areas.

Is there a country frog pond or city park pond within walking distance of your school? Do you have any large puddles on the playground?

Youngsters will develop a strong sense of interest and identification in any body of water by "adopting" it. Help them come to know it intimately. Make maps or charts. Measure its size and/or depth. Gather available information from your local library or historical society. Arrange interviews or classroom visits by knowledgeable persons.

Provide ways for the students to research human history, historical and current human uses, and biology of their local area. Observe the water through the seasons. Keep a group journal of writing and pictures resulting from their study.

The desire and potential for understanding other water environments will grow from their close relationships to the one at hand. Enjoy the process as well as the results of your learning. Make it fun for yourself and your students!

Annotated Filmography

There are many good visual materials on fresh and saltwater marshes, not very many on streams, and very few on lakes. This listing reflects that distribution. The classroom activity, "Film Field Trip and Follow-up" on page 11 is built around films *Marsh Adventure and The Salt Marsh: A Question of Values*. Further information on these two excellent films may be found in that activity.

Films

These are all 16 mm color films appropriate to grades five through nine. Where the annontation ends with "UMO", it is available for a fee from the Instructional Systems Center, Shibles Hall, University of Maine, Orono, Maine 04469. For the most recent free catalogue which contains listings on many marine education topics write to the Film Rental Library at the above address. Orders by mail should be at least two weeks in advance and many teachers order months ahead. Telephone orders for up to three films are accepted at (207) 581-7541.

Billion Dollar Marsh
This 1973 Time-Life film presents a logical sequence of scenes leading to solid conclusions favoring the conservation of marshes. It acknowledges economic and social pressures for marshland development and argues for orderly decisions rather than haphazard and irreversible development. The interviews with scientists are well done. It is forty-five minutes long.

Birds of the Marsh
The film focuses on birds of a fresh-water marsh but many would be found in a tidal marsh as well. Birds are shown feeding and caring for their young. It was produced in 1965 by Coronet Films and runs eleven minutes.

Cry of the Marsh
This 1969, twelve-minute film is one of powerful emotional impact, poetic beauty and drama. In early summer scenes, geese fly overhead and ducks feed in the water. The habitat of a marsh is shown in scenes of birds, fish, mammals, grasses, and wildflowers. Newly hatched ducklings huddle in their nests. Heavy machinery arrives to lay drainage pipe. The land is bulldozed and set afire, creating chaos among the wildlife; deer scatter and fish die for lack of oxygen; while one duckling seeks safety, its nestmates burn to death in their nest. There is no monologue but the film ends with Albert Schweitzer's quote, "Man has lost the ability to foresee and to forestall, he will end by destroying the earth."

The film will increase awareness and stimulate discussion but the duckling funeral pyre may be too much for younger children. Recommended with your discretion, UMO.

The Last Marsh
Filmed over a period of three years during all four seasons, many views of the marsh and its wildlife are presented. It shows the effects of pollution and development. This is a ten-minute film from Films, Inc., 1972.

Marsh Community
The film explains why the marsh is changing, illustrates living things and their adaptations to their marsh environment, and asks: What will become of these plants and animals as the marsh continues to be filled in through the process of natural succession? This Encyclopedia Britannica film is eleven minutes long and of excellent quality. UMO.

The Salt Marshes: Barrier Between Land and Sea
This film describes the ecology of salt marshes and shows many of their inhabitants. It discusses the marsh's usefulness for recreation, storm protection, and food production. It also shows major marsh plants and animals. The effects of oil spills are discussed. The script is by John and Mildred Teal, authors of the popular book, *Life and Death of the Salt Marsh*. Produced by Harper and Row, Inc. in 1973, it is twenty-four minutes long.

World in a Marsh
This twenty-two minute film shows the infinite variety of life forms of typical marsh fauna—muskrat, beaver, insects, amphibians, snakes, dragonflies, birds, and many others. Discusses adaptations. For older students primarily, the film was produced by McGraw-Hill. UMO.

Slide Shows

The Maine Audubon Society offers three excellent slide programs for a three dollar fee to schools. They are designed to be used in the carousels in which they are sent and should be

used only on Kodak slide projectors. Each comes with a complete script and covers its topic well.

Bog, Marsh, and Swamp Ecosystems
Freshwater Wetlands
Maine Saltmarshes

They may be obtained by writing to Mim Schneider, Teachers Resource Center, Maine Audubon Society, Gilsland Farm, 118 Old Route One, Falmouth, Maine 04105.

Videotapes

The Sea Behind the Dunes
Stillwaters

These videotapes are produced for WBGH in Boston as part of the Nova series for the public broadcasting network. They are excellent, but expensive. *Still Waters* is the story of a New England stream. *The Sea Behind the Dunes* is the story of a Cape Cod marsh. Further information is available from Time-Life Video, 100 Eisenhower Drive, Paramus, New Jersey 07652. Telephone: (201) 843-4545. If you wish to order, allow about four weeks for scheduling and about $75 for rental and postage/handling.

Annotated Bibliography

Books For Students

The study of wet environments encompasses a vast topical area and a wealth of printed material. The media specialist in your school, the resource center in your area, or the local librarian could provide you with book boxes to assist you in teaching this unit. The following are a few of our favorite books for students in grades five through nine. Books listed in the Teacher Resources section may also be appropriate for student projects or research.

Amos, William H. *The Life of the Pond.* New York: McGraw-Hill Book Company, 1967.

This volume is from the "Our Living World of Nature" series and, like the others, is excellent. The content covers habitats, transfers of energy, seasonal changes, and plant and animal adaptations. The appendix includes excellent suggestions for further exploration. Very good illustrations. Highly recommended.

Buck, Lewis: *Wetlands: Bogs, Marshes, and Swamps.* New York: Parents' Magazine Press, 1974.

Recommended for fifth and six grade students, this publication traces the development and describes the characteristics of bogs, marshes, and swamps. Wetland ecology never seemed so interesting. Clear descriptions and helpful illustrations make this a very readable book.

Buck, Margaret Waring. *In Ponds and Streams.* New York: Abingdon Press, 1955.

Full of scientifically accurate, readable information on common plants and animals, this is an excellent resource, illustrated by the author with black and white drawings. Very highly recommended. Another Buck volume, *Pets From the Pond* published by Abingdon in 1958 is also worthwhile for background on establishing aquaria or for student projects. It describes the details of collecting, feeding, and caring for plants, frogs, fishes, turtles, insects, and salamanders.

Cadbury, B. Bartram. *The Community of Living Things in Fresh and Salt Water.* Mankato, Minnesota: Creative Educational Society, Inc., 1956.

After all these years, this is still one of the best sources of information on brooks, streams, lakes, ponds, and marshes. It takes a community concept approach. Good for student reports.

Dobrin, Arnold. *Marshes and Marsh Life.* New York: Coward, McCann and Geoghegan, Inc., 1969.

A good introductory book for younger readers on fresh and salt water marshes through the seasons. Contains sections on marsh conservation and exploration.

Gorvett, Jean. *Life In Ponds.* Ill. Paxton Chadwick, New York: American Heritage Press, 1970.

Substantial reading for this age group, it contains much factual information on freshwater ecosystems. It is well-founded, accurately written, with many good illustrations.

Merrill, Daphne Winslow. *The Lakes of Maine.* Rockland, Maine: Courier-Gazette, Inc., 1973.

The premier publication covering virtually all the lakes of Maine. Maps and historical illustrations highlight this unique book. Well-written and well-organized, it is a lively resource for the lover of Maine lakes and lake legends. Good reading for teachers and students, especially to discover the local lake lore.

Niering, William A. *The Life of the Marsh.* New York: McGraw-Hill Book Company, 1966.

From "Our Living World of Nature" series, published in cooperation with The World Book Encyclopedia, this volume is complete and accurate. It is beautifully illustrated, well-organized, and has sufficient detail for in-depth study. Uses an ecological approach with emphasis on water's physical properties, plant and animal adaptations, and the flow of energy. Good glossary, diagrams, photographs.

Pringle, Lawrence. *Chains, Webs and Pyramids.* New York: Thomas Y. Crowell Company, 1975.

Written for readers at the younger end of our range for this unit, this book is a good introduction to energy flows for anyone. Clear explanations of food chains, food webs, and ecological pyramids—with the emphasis on wet environments. Includes references to several ecological studies. Recommended.

Pringle, Lawrence. *Wild River.* Philadelphia: J. B. Lippincott Company, 1972.

An unusual blending of aesthetics and science; this book contains hard core stream ecology and striking color photographs. It captures the spirit of that rare and valuable resource—a wild, clean

river. Highly recommended for teachers in its entirety and students, perhaps by chapters.

Russell, Franklin. *Watchers at the Pond.* New York: Alfred A. Knopf, Inc., 1961.

A masterpiece of the natural historian's art, this is the dramatic story of the cycle of a year within the teeming universe of a pond. Students will find the author's vivid style makes the pond come to life. Good for reading aloud to classes or for independent reading by older students. A first-rate book.

Smith, Frances C. *The First Book of Swamps and Marshes.* New York: Franklin Watts, Inc., 1969.

The title should not mislead you. This is a substantive book for fifth and sixth graders. Covers various types of wet environments across America. The explanations are clear. The attitude is one of concern.

Snow, John. *Secrets of a Salt Marsh.* Portland, Maine: Guy Gannett Publishing Company, 1980.

Written and photographed by life sciences teacher at Scarboro Junior High School, this book was written to increase awareness of the value of coastal wetlands as a nursery and breeding ground. It is an excellent resource both for any teaching about salt marshes of New Hampshire and Maine.

Ursin, Michael J. *Life In and Around the Salt Marshes.* New York: Thomas Y. Crowell Company, 1972.

A good field guide to the marsh with drawings, descriptions, and color prints of commonly observed plants and animals. This book is listed because it is easy to use, but there are some inaccuracies; it should not be your only reference.

Books for Teachers

These are a few of the very best. They have been chosen with the goal of developing your background on the topics, but could be shared with youngsters as well.

Andrews, William A., editor. *A Guide to the Study of Freshwater Ecology.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972.

An excellent volume in the "Contours: Studies of the Environment" series. It is precise, innovative, and well-written. This volume uses a very comprehensive ecological approach. Best used as a resource for teachers; it contains solid background information on lakes, ponds, rivers, streams. Excellent suggestions for classroom and field studies for eighth and ninth grade.

Conant, Roger. *A Field Guide to Reptiles and Amphibians of Eastern and Central North America.* Boston: Houghton Mifflin Company, 1975.

Good as a reference, broad in content; it contains accurate and detailed descriptions. From the Peterson Field Guide Series sponsored by the National Audubon Society and the National Wildlife Federation.

Horwitz, Elinor Lander. *Our Nation's Wetlands: An Interagency Task Force Report.* Washington: U.S. Government Printing Office, 1978.

This booklet, written by several government agencies, attempts to provide a broad and balanced review of the status of the nation's wetlands. It describes how wetlands were formed, various types of wetlands, and the useful functions they serve in their natural state. Many important issues are addressed concerning the future of this resource. This 70-page booklet is for sale by the Superintendent of Documents, U.S. Government Printing Office. Washington, D.C., Stock Number 041-001-00045-9 for $3.25. We very highly recommend it for your background information or advanced students. It is outstanding visually.

Klots, Elsie, B. *The New Field Book of Freshwater Life.* New York: G. P. Putnam's Sons, 1966.

Not so "new" anymore, but a standby for field trips or classroom projects—for teacher or student use. It is somewhat technical but you can use only the information you need.

Marshall, Alexandra. *Still Waters.* New York: William Morrow and Company, Inc., 1978.

A magnificent book—poetic, beautiful and good for this age group if presented sensitively. It is the story of a year at a North American fresh water pond. Superb illustrations and color plates help the reader to appreciate pond ecology. The book was prepared in conjunction with the Nova film, "Still Waters."

Teal, John and Mildred. *Life and Death of the Salt Marsh.* Boston: Little, Brown and Company, 1969.

The classic, responsible for much of the public awareness of the marsh, is good for teacher background or reading aloud to your class. Topics include birth and death of marshes, their ecology, and conservation. Beautiful black and white drawings by Richard Fish. Recommended as eminently readable and the finest single book on the subject.

A Field Guide to the Aquatic Insect Groups

Most aquatic insect groups inhabit water only in the juvenile stages. The adults of these groups are completely terrestrial, and are usually free-flying insects.

Mayflies
Ephemeroptera

The aquatic juveniles or nymphs are found in both standing and running water but are most common in rocky-bottomed streams. Some are found in very fast currents. Most species of mayflies complete their development in three to six months, but some may require a year or even two. The nymphs of most mayfly species feed on fine organic particles or algae. Some are carnivorous. Distinguishing characteristics of mayfly nymphs are the abdominal gills which may be feathery, plate-like, or leaf-like and the presence of two or three "tails" at the end of the abdomen.

The adult mayfly is a familiar insect with upright wings, long tails, large eyes, and a soft body. The adults are non-feeding and live for a very short time, usually a day or two.

Dragonflies and Damselflies
Odonata

The nymphs or naiads of damselflies and dragonflies are common in lakes, ponds, and streams. The nymph stage can last anywhere from a few weeks to several years depending on the species. All nymphs are carnivorous.

The distinguishing feature of juvenile *Odonata* is the elbowed, extensible labium or lower lip which is used to capture prey. Most nymphs are fairly slender creatures with long, thin legs. Damselfly naiads are differentiated from those of dragonflies by their long gills, found at the end of the abdomen.

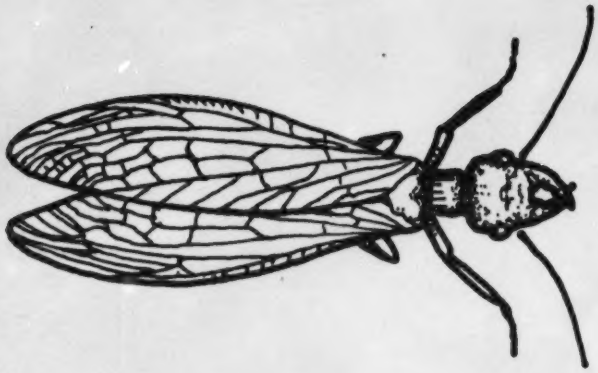
Adults are conspicuous, long-lived, common insects recognized by their long thin bodies and large outstretched wings. They are known by a variety of names and, contrary to the belief, are not at all poisonous. All adults are predaceous—catching flying insects on the wing.

Stoneflies
Plecoptera

Stonefly nymphs are most commonly found in clean and cold rivers, streams, and sometimes lakes. These insects are perhaps the most intolerant to pollution of all aquatic groups and are often useful as indicators of water quality. The nymph developmental period can last two to three years, but most species complete their development in a single year. *Plecoptera* nymphs can be herbivorous, carnivorous, or feed on organic detritus. Some species may exhibit several different modes of feeding as they develop.

Stonefly nymphs are typically slender, soft-bodied insects with fairly long, thread-like antennae. Most characteristic are the two slender cerci or tails at the end of the abdomen.

Adults are drab, soft-bodied insects with a slender, flattened appearance. The wings are usually elongated. Some species, however, are wingless. The adults are poor fliers and are usually found on stream-side vegetation, where they may feed on various plants. Most live about a month.



Dobsonflies, Fishflies, and Alderflies
Neuroptera or *Megaloptera*

Larvae of these insects can be found in lakes, rivers, and streams throughout the world. Some species are the largest aquatic insects likely to be encountered. The great majority are predaceous. Larval dobsonflies and fishflies are called hellgrammites and are often found on submerged logs. The larvae are elongate, slender, soft-bodied insects often having large mandibles. There are usually slender filaments projecting from the abdomen, and the body may terminate in a single filament.

Adults are never very common and are found nocturnally near bodies of water. They have fairly large, many-veined wings which are held over the soft body. Most have long antennae and large mandibles. The adults are short-lived.

Caddisflies
Trichoptera

Caddisflies are one of the largest groups of aquatic insects and are found in all types of aquatic habitats. Many are remarkable for their casemaking behavior. They construct shelters of small stones, sticks, or plant fragments which are carried about by the insect. Other stream-inhabiting caddisfly larvae construct nets of silk which trap small food particles in the current. *Trichoptera* larvae typically feed on algae or decaying plant material, but some are carnivorous. Most complete their development in a single year. Casemaking larvae are easily recognized by their characteristic cases. The typical caddisfly larva is a fleshy, worm-like insect resembling a caterpillar. There are usually small hooks at the end of the abdomen and slender finger-like gills on its sides.

Adult caddisflies are fairly small, dull-colored insects which resemble moths. The wings are hairy and held over the body; the antennae are typically long and slender. Most are nocturnal in habits and found near water. Occasionally, great numbers of adult caddisflies emerge from rivers.

Moths
Lepidoptera

A few species of moths are truly aquatic in their larval stage. The caterpillars may be found among rocks in streams but most are associated with aquatic plants. These species are found in silk shelters on the undersurfaces of the leaves. All aquatic *Lepidoptera* feed on plant material of some sort.

The larvae are typical caterpillars in appearance. Some have finger-like gills on the abdomen. The adult moths are usually quite small and grey or brown in color.

Flies
Diptera

Fly larvae occur in virtually every imaginable type of aquatic habitat—from cold streams to hot springs. Some even inhabit natural petroleum pools. A number of species are found in coastal marine waters. Larvae feed on many types of plant, animal, and detrital food; even closely-related species can show large differences in feeding habits. The larvae of *Diptera* may be found buried in bottom mud or gravel, under stones, attached to vegetation, or free-swimming. Many species are able to complete two or more generations in a single year.

Among the large number of flies possessing aquatic juvenile stages are a number that are important to humans. Mosquito larvae occur world-wide in northern areas. Deerfly and horsefly larvae occur in salt and freshwater swamps, marshes, and ponds

in many parts of the world. Larval midges (called "biting punkies" or "no-see-ums") can be found in lakes, rivers, and seashore areas. Besides being biting pests, many of the adults of these groups are vectors of very important human and animal diseases such as yellow fever, malaria, and anthrax.

Different kinds of fly larvae show a wide range of body sizes and shapes. Typically, they are soft-bodied, worm-like creatures which lack jointed legs, though a variety of leg-like appendages can be found. The head is often reduced or absent altogether.

Adult flies are familiar insects. They possess only one pair of wings and many are skillful, rapid fliers.

True Bugs
Hemiptera

A wide variety of true bugs can be found in water habitats. Most are free-swimming insects like water boatmen, back-swimmers, and giant water bugs. Others, such as water scorpions, live among aquatic vegetation. Some inhabit the surface film like water-striders. The great majority of aquatic *Hemiptera* are predaceous in both juvenile and adult stages. Some larger specimens are able to feed on small fish and tadpoles. The bugs themselves possess scent glands which make them distasteful and relatively resistant to predation.

The juvenile forms or nymphs generally resemble the adult bugs but lack functional wings. All *Hemiptera* possess a pointed beak which is used to suck fluids from their prey. Most adults are able to leave the water and fly, though some lack wings altogether.

Two large groups of insects include many species which are aquatic in both juvenile and adult stages.

Beetles
Coleoptera

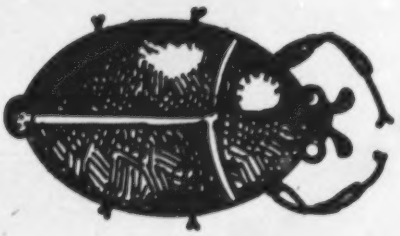
Beetles are the most numerous insects on earth, and the aquatic *Coleoptera* is one of the largest groups of freshwater insects. They are found in a great range of aquatic habitats. Juveniles or larvae usually inhabit cracks, crevices, or burrows. Adults may occur in similar situations or are free-swimming. Both adults and larvae show a wide range of carnivorous and herbivorous feeding habits. All adult beetles, at least to some degree, are dependent on atmospheric air for their respiration.

The juvenile beetles are quite variable in form. Typically, they are fairly elongate, somewhat soft-bodied insects with fairly long legs, well-developed mandibles, and antennae. Many have some type of projections on the body. The adults are compact, rounded, or oval hard-bodied insects with wing covers concealing the abdomen from above. Most are able to fly, at least on occasion.

Study Guide to Common Insects and Plants of Northern New England Wetlands

Whirligig Beetles

These beetles use their short, paddle-shaped middle and hind legs for skimming across the surface of the water and for diving beneath the surface. Divided eyes permit them to see both above and below the water at the same time while moving along the surface. The larvae are carnivores; the adults are scavengers. Many of the fifty North American species give off a strong odor when captured. These beetles lay white, oval-shaped eggs under lily pads or pondweed leaves and stick them to the plants with a glue-like substance.



Dragonflies and Damselflies

Dragonflies hold their paired wings in a horizontal position while resting. The smaller, more delicate damselflies hold their wings folded and in line with their bodies while at rest. The dragonfly nymph is broad with no gills. The slender damselfly nymph has three feathery gills at the end of the abdomen. Both dragonflies and damselflies mate in flight. The female then deposits the eggs in the water or on a floating object where they hatch into nymphs. The entire life cycle takes from three months to five years, depending upon the species.

Cordgrass

Spartina alterniflora or cordgrass covers large areas of salt marshes where it flourishes along the edges of tidal streams and in deep marshes. The straight stems and long, strong leaves reach heights of 1.5 meters or more under favorable conditions.

Sedges

Sedges are grass-like plants with stems which are triangular in cross-section and with three rows of leaves per stem. The basal sheaths of the leaves grow tightly to the stem.

Bur-reeds

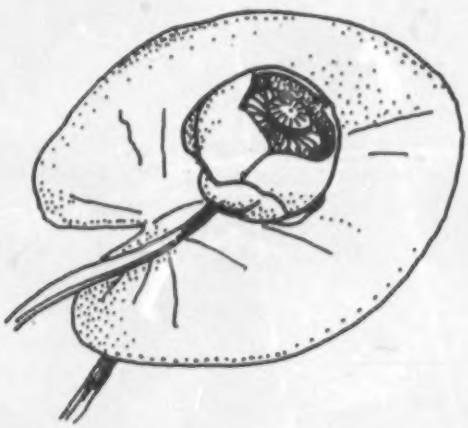
Growing in marshy pond borders among the pickerel weeds and cattails, you can often find bur-reeds. These plants have reed-like leaves and clusters of closely packed nutlets forming bur-like bruits. They range in height from thirty centimeters to one meter.

The Scented White Pond Lily

These white and fragrant flowers are surrounded by dark green leaves with reddish-purple undersides. The leaves are large, and roughly round with notches. Numerous insects and other small aquatic animals use the underside of these large leaves for hatching sites.

Yellow Water Lily

This yellow water flower has heavier leaves and stems than the white pond lily. The oval-shaped leaves are about twenty centimeters across. Insects are responsible for the cross-pollination in these aquatic plants.



Blue Flag

This showy, blue, aquatic iris owes a good part of its beauty to the brightly colored sepals which are larger than the petals.

Caddisflies

This aquatic insect is an important food source for many fishes, including the trout. The larval form of the Caddisfly constructs a tube-like house of leaves, bark, twigs, or some other suitable material and lives in that house. The larvae are so distinctive in the type of tube they build that they can often be identified by the types of houses they occupy. Most of the Caddisfly's brief life is spent in the larval form.

Mosquito

Female mosquitoes lay their eggs in any standing water after having had a meal of blood. The larvae are often called wigglers because of the manner in which they wiggle from the surface where they breathe to the bottom where they feed. The mosquito pupa lies close to the surface of the water with its back up to the surface where the air tubes open into the atmosphere. Mosquitos are very hardy and can easily survive many sorts of difficult conditions.

Cattails

Typhaceae

Spreading root systems of the cattail give rise to a rapidly expanding population of plants in favorable marsh and waterside environments. These plants grow to heights of up to 2.5 meters. The plants provide a habitat for insect populations throughout the year.The plants have a staminate flower occuring on a thin spike above the more commonly recognized brown pistil.

Marsh Adventure Chart

List as many species as you can in each category using the film or your personal knowledge. List also relationships between species.

Species Found in Northern New England Marshes						
Birds	**Plants**	**Insects**	**Mammals**	**Reptiles**	**Amphibians**	**Other**
Relationships. . .						

Marsh Pre-Test

1. What is a marsh?
2. List five marine organisms you might commonly find living in a Northern New England marsh.
3. List five types of plant life you might find in Northern New England marshes—either salt or fresh water.
4. Name several contributions marshes make to humankind.
5. What values do marshes have for animal life?
6. In what ways do humans affect the marsh?

Marsh Post-Test

1. Describe the food chains found in a marsh. You may use a diagram if you wish.
2. How are marshes being destroyed?
3. What is being done to preserve the marshlands?
4. What types of animal and plant life may be found in the marsh? List at least ten.
5. In what ways are marshes important?
6. Should all Northern New England marshes be set aside as nature sanctuaries? Why or why not?

Stream Pre-Test

1. Define ecology.
   Define stream.
2. What kinds of plants and animals can you find in a stream?
3. Have you ever been to a stream to study it or play near it? If yes, describe what you remember about the stream. Was it in the fall, winter, spring or summer?
4. Where does a stream get its water?
5. Does a stream change as the weather changes?
6. What is pollution? How can you tell a stream is polluted?
7. What things do organisms need in order to live?
8. Describe how humans use the stream.

Stream Post-Test

1. What is a stream?
2. Name as many stream organisms as you can. Describe features which were unusual about organisms you found. Draw one organism.
3. What is adaptation?
4. Describe a food chain among organisms in the stream.
5. Name several ways you gathered information or samples from the stream.
6. List ten adjectives to describe the time you spent outdoors studying the stream.
7. Name ways in which you can tell if a stream is polluted.
8. Can you think of a class project that would be fun to do to help others understand the importance of streams in our environment?